UNIVERSITY OF ALBERTA

AN ASSESSMENT OF WIND EROSION DAMAGE TO ALBERTA SOILS

A THESIS

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ABSTRACT

THE OBJECT OF THIS WORK WAS TO STUDY THE DATA ON WIND IN ALBERTA AND TO EVALUATE THE DAMAGE DONE TO ALBERTA SOILS BY EROSION. AH, AA, AND B HORIZON SOIL SAMPLES WERE COLLECTED FROM FOUR SOIL TYPES: DRUMHELLER CLAY, LETHBRIDGE LOAM, ANTLER LOAM AND PEACE HILLS SANDY LOAM. THE SOILS WERE SUBJECTED TO VARIOUS PHYSICAL AND CHEMICAL ANALYSES. A GREENHOUSE EXPERIMENT WAS ALSO SET UP TO TEST THE EFFECT OF NITROGEN AND PHOSPHORUS FERTILIZERS ON RESTORING THE FERTILITY OF SOILS EXPOSED TO EROSION.

THE RESULTS SHOW THAT EROSIVE WINDS OCCUR MORE FREQUENTLY IN THE SOUTHERN PORTION OF THE PROVINCE. THE LOW PRECIPITATION AND LACK OF SNOW COVER PUT THE AREA OF LETHBRIDGE, IN PARTICULAR, IN A VERY CRITICAL POSITION.

THE CHEMICAL AND PHYSICAL ANALYSES SUGGEST THAT THE CULTIVATED SOILS IN LETHBRIDGE HAVE LOST THE AH AND MOST OF THE B HORIZON AS A RESULT OF EROSION AND CULTIVATION. HOWEVER, THE CULTIVATED SOILS AT THE PRESENT TIME ARE QUITE RESISTANT TO

FURTHER EROSION BECAUSE OF THE REMOVAL OF FINE AGGREGATES.

The pot experiment shows that the fertility and productivity of the Aa horizon of Lethbridge loam is lower than the Ah horizon. Fifty pounds per acre of nitrogen or one hundred pounds per acre P_2O_5 pushed up the productivity of Aa to the level of Ah horizon. Wind erosion did not alter the fertility of the other three soil types. However the B horizon in the Drumheller clay, which will eventually be exposed by erosion, needed one hundred pounds per acre of nitrogen to restore its fertility.

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INTRODUCTION

Soil erosion is one of the most serious menaces to our land and constitutes a direct threat to our existence. Since the dawn of history, civilizations have arisen in areas where agriculture has prospered and they have endured where the soil was conserved. Many ancient civilizations have declined as a result of the neglect of conservation measures.

In 1905, Alberta became a province with a total area under field crops of 600,000 acres. In the spring of 1920, the first serious wind erosion damage to Alberta soils was recorded (40). A series of wind storms filled road-side ditches and covered fences with rich wind-blown top soil. It was estimated that more than 75,000 acres of grain were severely damaged that year in the area now known as the Lethbridge Northern Irrigation District.

Because of the continuous clearing of the native cover and the bringing of new land under cultivation, areas exposed to wind erosion are no longer confined to the southern districts. Many areas in the central part of the province are being affected. It was reported in a recent publication (1) that damage by wind in 1959 was highest in the Drumheller area (300,000 to 350,000 acres), followed by the Hanna area (200,000 acres). Lethbridge came in third place (35,000 to 60,000 acres). Other areas affected by erosion totalled 145,000 acres. It was also noted from the same report that wind erosion damage at Medicine Hat was negligible.

Since no recent analytical data dealing with the problem were available, it was the aim of the present study to evaluate the seriousness of the situation. Do physical and chemical analysis of the virgin and cultivated soils reveal any important differences resulting from erosion? Are eroded soils markedly inferior to non-eroded soils? If they are, can their fertility be restored economically? How serious actually is the damage that has been done to Alberta soils? The present study is aimed at finding

answers to these questions.

LITERATURE REVIEW

Definition of Erosion

In a broad geologic sense, erosion means removal of the earth's mantle of soil by the action of water and wind. However, not all kinds of erosion are destructive. Many fertile soils were formed, according to the U.S.D.A. soil survey manual (50), as a result of erosion of mountains and hills and the redeposition of the transported materials in far away level areas. It has also been stated that about one-third of the world's population is being supported by crops growing on alluvial soils. The soil survey manual points out that in applied soil science the term soil erosion is used in a very restricted way. It is often used to indicate accelerated soil erosion. resulting from the disturbance of the natural land scape through human activities and erosive agents. On the other hand, Kohnke (34) suggested a more precise definition - "Soil erosion is the process of detachment and transportation of soil material by natural agents." He pointed out that soil particles at the

surface adhere to the soil body and hence they must be separated from it before they are removed.

Soil Properties That Affect Wind Erosion

The most important soil properties that affect erosion are 1. texture, 2. relative quantity of water-stable soil aggregates greater than 0.5 mm. as well as those smaller than 0.05 mm. in diameter, 3. organic matter content, and 4. calcium carbonate content.

Effect of Texture on Wind Soil Erosion

According to Chepil (18, 21) soils of coarse and fine texture were more susceptible to erosion than soils with medium texture. This was attributed to the weak coherence of the coarsely grained soils and the tendency of fine textured soils to break down by wetting and drying, and freezing and thawing. In soils with medium texture, content of silt and clay particles was enough to increase their cohesion but insufficient to cause the clods to break down. Fifteen per cent of clay was the minimum amount necessary to ensure cloddiness, while

amounts more than twenty-seven per cent were detrimental. Soils with more than eighty per cent sand were more susceptible to wind erosion than any other soil.

Effect of Water-Stable Soil Aggregates on Soil Erosion

Chepil (9, 19) considered the water-stable soil aggregates to be the most resistant soil constituents to erosive agents. Soils susceptible to erosion were found to contain many of the water-stable soil aggregates between 0.05 and 0.5 mm. in diameter, while soils resistant to erosion were found to contain a large amount of water-stable soil aggregates greater than 0.5 mm. in diameter as well as many water-stable soil aggregates and particles smaller than 0.02 mm. in diameter. A high correlation was also found between the resistance of soils to erosion and the content of water-stable soil aggregates greater than 0.84 mm. in diameter.

Effect of Organic Matter Content on Soil Erosion

Moss (39) was one of the earliest to report that, contrary to the common belief, drifting occurred in soils rich in organic matter. On the other hand, Yakubov (53) in the U.S.S.R. found that

organic matter was not always inducive to wind erosion. However, Chepil (22) pointed out that the process of decomposition caused the formation of wind resistant soil aggregates which lasted during the earlier stages of organic matter decomposition. Straw, for example, was found to increase water-stable soil aggregates greater than 0.84 mm. in diameter. Humus, on the other hand, formed micro-structural elements and increased the susceptibility of soil to erosion appreciably.

Effect of Calcium Carbonate Content on Soil Erosion

Hopkins (33) and Bradfield (5) recognized calcium carbonate as an important factor in stimulating soil erodibility. Hardt (32) in Bavaria, as well as Blumel (4) in Austria affirmed the same fact. According to the latter, soils susceptible to erosion in southern Vienna were humus calcareous. Chepil (20) found that the addition of one to five per cent calcium carbonate to clay loam soils had decreased their cloddiness, while these additions to sandy loam soils had decreased their erodibility. Generally both calcium carbonate and humus, Chepil (22) added,

have always caused an increase in aggregation but at the expense of decreasing water-stable and erosion resistant water-stable soil aggregates smaller than 0.05 mm. in diameter. The newly formed aggregates were within the critical limits of 0.05 to 0.50 mm. in diameter and thus soils rich in humus and calcium carbonate were found to be very susceptible to wind erosion.

WIND STUDIES IN RELATION TO SOIL ERODIBILITY

The nature of wind at the soil surface as well as the degree of roughness of soil surface are very important for the development of wind erosion.

Investigations by Chepil (10, 11) and Yakubov (52) indicated that wind velocity is sharply reduced in the layer near the ground surface and it becomes practically zero at the very surface of the ground. A tenacious layer of slowly moving air develops directly in the soil surface with a thickness of 0.05 mm. Thus, in the earlier stages of wind erosion, particles protruding above that layer are the first to be picked up and blown away.

Chepil and Milne (25) found that all erosive winds are turbulent. Soil erosion with non-turbulent winds has never been recorded. Turbulence was found to arise from the effects on the air stream of soil roughness and by the difference between soil and air temperature. Turbulence has been found to increase the surface forward velocity of the wind and hence the momentary frictional force of the wind against the ground.

Three types of soil movement by wind were recognized by Chepil (10, 11) and Kohnke (34): saltation, suspension, and surface creep. Saltation refers to the short jumps of particles (0.1 to 0.5 mm. in diameter) as a result of variation in wind velocity with different distances from the ground. The high pressure at the top of these particles (0.1 to 0.5 mm. in diameter) causes them to spin rapidly with the top moving in the same direction as the wind and the bottom moving in an opposite direction. As the air at the surface spins with the grain, a partial vacuum is created above the particle and air is compressed below it. Therefore the grain tends to jump into the air. Its horizontal momentum causes it to

RISE AT AN ANGLE OF SEVENTY-FIVE TO NINETY DEGREES, AND TO CLIMB SIX TO TWELVE INCHES AND SOMETIMES OVER TWO FEET. AS THE PARTICLE IS LIFTED UP, THE SPIN TENDS TO SLOW DOWN SINCE THE PARTICLE BEGINS TO ENTER LAYERS WHERE THE WIND IS SUBSTANTIALLY FASTER. HAVING LOST ITS UPWARD IMPULSE, IT IS CARRIED WITH THE WIND IN A DESCENDING DIRECTION. AS THE PARTICLE STRIKES THE GROUND, CAUSING OTHER SMALLER PARTICLES (0.05 TO 0.002 MM. IN DIAMETER) TO MOVE, THE SECOND TYPE OF MOVEMENT, IN SUSPENSION, TAKES PLACE, WHILE LARGER PARTICLES (0.5 TO 3.0 MM. IN DIAMETER), BEING TOO HEAVY, ROLL ALONG THE SURFACE, NOT FLYING OR JUMPING. THIS LAST MOVEMENT IS TERMED SURFACE CREEP. THE PROPORTION OF THESE THREE TYPES OF MOVEMENT WAS FOUND TO VARY GREATLY WITH DIFFERENT SOILS. HOWEVER CHEPIL (23) FOUND THAT ON THE AVERAGE FIFTY TO SEVENTY-FIVE PER CENT OF THE SOIL MASS WAS CARRIED IN SALTATION, THIRTEEN TO FORTY PER CENT IN SUSPENSION, AND FIVE TO TWENTY-FIVE PER CENT IN SURFACE CREEP.

THE AMOUNT OF SOIL MASS TRANSPORTED BY WIND WAS FOUND BY CHEPIL (11) TO BE GREATEST NEAR THE GROUND SURFACE AND RAPIDLY DECREASING WITH HEIGHT. IT WAS ALSO FOUND THAT WITH WIND VELOCITY TWELVE TO

twenty miles per hour, sixty to eighty per cent of the soil mass was transported at a height of zero to two inches, more than ninety per cent below one foot and very insignificant amounts were carried above three feet.

The threshold velocity, that is, the minimum velocity required to dislodge or initiate and cause movement of soil was recognized by Chepil (10, 11) and Yakubov (52) as another important factor for the development of wind erosion. The threshold velocity was least for particles 0.1 to 0.5 mm. in diameter, 3.5 to 4 meters per second. The threshold velocity for particles greater than 0.1 mm. in diameter increased with an increase in diameter, while with particles less than 0.05 mm. in diameter, the threshold velocity increased with a decrease in particle size. Silt particles (0.005 to 0.01 mm. in diameter) did not move even under a velocity of 16.5 meters per second.

Various authors have submitted different figures for soil eroding winds. However most of these data were not fully specified. The heights at which wind speeds were recorded were either not men-

TIONED OR WERE TOO HIGH TO BE OF ANY IMPORTANCE IN DEALING WITH A SURFACE PHENOMENON SUCH AS WIND EROSION. NEVERTHELESS CHEPIL (10, 11) AND YAKUBOV (52) CONSIDERED IT TO BE TEN TO ELEVEN MILES PER HOUR AT A HEIGHT OF ONE FOOT. THIS HEIGHT WAS USED FOR TWO MAIN REASONS: 1. MORE THAN 90 PER CENT OF SOIL MASS IS USUALLY CARRIED BELOW ONE FOOT; AND 2. PARTICLES MOVING IN SALTATION, WHICH INVOLVE 50 TO 75 PER CENT OF SOIL MASS, SELDOM JUMP HIGHER THAN ONE FOOT.

EFFECT OF WIND EROSION ON THE PHYSICAL PROPERTIES OF SOILS

SOIL TEXTURE IS THE MAIN PHYSICAL PROPERTY THAT IS USUALLY ALTERED BY THE WIND. THE CHANGES IN OTHER PHYSICAL PROPERTIES ARE JUST A CONSEQUENCE OF THE ALTERATION IN TEXTURE.

MOSS (29) IN AN EARLY INVESTIGATION CONDUCTED IN SASKATCHEWAN FOUND THAT THE AVERAGE MECHANICAL COMPOSITION OF FINE TEXTURED SOILS AND THEIR DRIFT WERE ALMOST IDENTICAL. BOTH THE SOIL AND THE DRIFT WERE PLACED IN THE CLAY CLASS. ON THE OTHER HAND, THE DRIFT FROM SANDY LOAM SOILS WAS SET

in the sand class and that from medium textured soils was set in the light loam class. Daniel and Langham (28) in Oklahoma showed that the greatest difference in the mechanical composition of drift, cropped, and virgin soils occured in the coarse and medium textured soils. Similar trends were found by Erdman (31) in Alberta. Winds had sifted out one-half of the silt and one-quarter of the clay from the accumulated drift of sandy loam and fine sandy loam soils. The accumulated drifts from loam and silt loam soils showed a loss of 27 per cent silt and a slight loss in clay. Soils removed by wind from clay and clay loam soils were practically identical in their physical composition to the drift. Adding to the above observations it can be noted that according to Chepil (18) and Yakubov (53), two basic types of wind erosion occur on different soils: 1. massive, and 2. selective. Massive blowing occurs in soil with fine texture causing a slight alteration in the mechanical composition of the soils and their drift. On the other hand, selective wind erosion occurs in soils with coarse and medium texture. In this case wind erosion involved the removal of fine particles

while coarse particles remained in place.

Effect of Wind Erosion on the Chemical Changes and Fertility Status of Soils

Changes in the organic matter content as well as nitrogen and phosphorus content brought about by wind erosion have received a great deal of attention from agronomists.

Investigation in the high plains of Oklahoma by Langham (36) showed that from 1933 to 1937, the organic matter and total nitrogen content had decreased 22.6 and 20.3 per cent respectively. It was reported that the drifted material had an average of 24.5 per cent less organic matter and 28.0 per cent less nitrogen than samples obtained from virgin soils. However some of the drifts from medium and fine textured soils contained higher percentages of these constituents than the virgin soils. According to Doughty (30) erosion removed ten to sixty per cent organic matter while losses in phosphorus were insignificant. Plants growing on the eroded and the non-eroded soils showed considerable variation in their nitrogen content and very minute

differences in their phosphorus content. Chemical analysis of soils in the Pavlodor region by Smirnova (45) showed that wind had removed 37 per cent fine soil and 67 per cent humus. Losses in potassium, nitrogen, and phosphorus, were 35, 37, and 15 per cent respectively. Soil material deposited on snow in Iowa by a dust storm originating in Texas contained, according to Benett (3), ten times as much organic matter, nine times as much nitrogen, and one and a half times as much potassium as there was in the dune sand piled up where the dust had originated.

Erdman (31) in Alberta found that drifts from coarse textured soils contained on the average one-half as much nitrogen and organic matter as the normal cultivated soil while the exposed sub-surface had lost less than one-half of its nitrogen and organic matter content. On the other hand drifts from medium textured soils showed a greater variation. They varied from gains to losses with an average loss of 15 per cent. The exposed sub-surface lost 16.7 and 17.8 per cent nitrogen and organic matter respectively. Drifts from fine textured soils showed

THE SAME TRENDS AS MEDIUM TEXTURED SOILS. HOWEVER THE EXPOSED SUB-SURFACE CONTAINED 12.7 PER CENT LESS NITROGEN AND SEVENTEEN PER CENT LESS ORGANIC MATTER. HENCE IT WAS CONCLUDED THAT THOUGH MODERATE TO SEVERE LOSSES HAD TAKEN PLACE ON FINE TEXTURES SOILS, THE ACTUAL LOSSES EXCEEDED THOSE OF MEDIUM TEXTURED SOILS. CONSEQUENTLY THIS LED TO THE ASSUMPTION THAT VERY LITTLE SELECTIVE EROSION OCCURRED IN FINE TEXTURED SOILS.

FROM THE POT EXPERIMENT CARRIED OUT BY ERDMAN (<u>OP. CIT.</u>) A STRIKING DIFFERENCE WAS FOUND BETWEEN PLANTS GROWING ON ERODED AND NON-ERODED FINE SANDY SOILS. THE AVERAGE TOTAL WEIGHT OF PLANTS GROWING ON DRIFT WAS LESS THAN HALF THAT GROWING ON NORMAL SOILS, WHILE IT WAS ONE-FIFTH FOR PLANTS GROWN ON EXPOSED SUB-SURFACE. RESULTS IN SILT LOAM SOILS WERE LESS STRIKING. ON THE OTHER HAND AIR-DRY WEIGHTS OF PLANTS GROWN IN ERODED AND NON-ERODED LOAM SOILS WERE IDENTICAL. THE CLAY SOILS PRODUCED SIMILAR WEIGHTS OF PLANTS ON BOTH NORMAL SOILS AND EXPOSED SUB-SURFACE, BUT THOSE ON ACCUMULATED DRIFT WERE SOMEWHAT HEAVIER. NO CORRELATION WAS FOUND BETWEEN PERCENTAGE NITROGEN IN PLANTS GROWN ON

ERODED OR NON-ERODED SOILS. HOWEVER, A DIRECT RELATIONSHIP WAS FOUND BETWEEN PERCENTAGE NITROGEN IN THE SOIL AND TOTAL WEIGHTS OF PLANTS.

THE EFFECT OF CULTIVATION ON FERTILITY CHANGES IN SOILS

MANY WORKERS HAVE ESTABLISHED THE DEFINITE RELATIONSHIP BETWEEN CULTIVATION AND THE DEPLETION OF SOIL FERTILITY. CULTIVATION CAN DEPLETE THE SOIL BY EITHER THE REMOVAL OF SOIL NUTRIENTS BY GROWING CROPS OR BY INCREASING MICROBIAL ACTIVITIES AS A RESULT OF DISTURBING THE SOIL AND EXPOSING SUB-SURFACE, RESULTING IN A QUICKER DECOMPOSITION.

IN 1917 SWANSEN OF KANSAS (48) REPORTED, UPON COMPARING CROPPED AREAS VERSUS THE VIRGIN SOILS, THAT THE CROPPED SOILS SHOWED A DECIDED LOSS IN SULPHUR, NITROGEN, AND ORGANIC MATTER. THE PERCENTAGE LOSS IN SULPHUR WAS PROPORTIONAL TO THE LOSS IN ORGANIC MATTER. HOWEVER, IT WAS POINTED OUT THAT THE LOSS IN SULPHUR DUE TO CROP UPTAKE WAS INSIGNIFICANT COMPARED WITH THE TOTAL AMOUNT THAT HAD DISAPPEARED AS A RESULT OF SULPHOFICATION.

Several attempts have been made to evaluate the losses in soluble plant nutrients upon cropping by determining the rate of formation of soluble plant nutrients using the freezing point depression technique on several virgin and the corresponding depleted soils. McCool (37) found that generally the concentration of soil solution of the virgin soil was much greater after a ten day period at twenty-five degrees centigrade. Millar (38) reported a definite correlation between the difference in the rate of formation of soil solution of several depleted and virgin soils and the observed difference in productiveness. Shedd (43) found the total phosphorous and that soluble in 0.2 normal nitric acid to be greater in seventeen virgin soils than in the corresponding cropped soils. In a majority of cases more calcium was found in the virgin soils than in cropped soils.

Caldwell _et al._ (6) estimated fertility losses in the different soil zones in the prairie provinces of Canada. The cultivated black, the dark brown, the brown, and the grey soils were found

to have lost eighteen, twenty-two, twenty, and thirty-five per cent of the original nitrogen respectively in the surface six inches of soils. It was concluded that approximately one-third to one-half of the nitrogen losses were a result of crop removal.

Chepil et. al. (24) found that nine inches of soil on the average in western Kansas had been lost within the last twenty years due to cultivation and continuous drifting. Long time cultivation resulted in a type of structure more resistant to erosion. This was a result of the removal of the coarse textured and poorly structured A horizon and the exposure of fine textured and structurally developed B horizon. The amount of water-stable aggregates greater than 0.5 mm. in diameter was greatest for the old cultivated and least for newly broken soils. Another investigation carried out in Kansas by Olmstead (42) showed that all cropping systems that included small grains, continuous row crops, and rotations including fallow, showed no significant differences in water-stable aggregation. However, all plots showed a loss of about eighty per cent of the initial aggregation since they were broken in 1902.

ESTIMATING ERODIBILITY

Various attempts have been made to evaluate soil erodibility from the relation between it and the various soil structural factors. The factors that have been considered in this regard are the proportion of the erodible fraction to the drag velocity of the wind, the amount of non-erodible fraction and the various water-stable aggregates (9, 13, 16).

The relationship mentioned above was quite complicated especially in considering the meaning of erodible and non-erodible fractions since they were affected primarily by wind velocity. However, Chepil (7) reported that the dividing line between erodible and non-erodible fraction was about 0.84 mm. in diameter. Soils with more than fifty to sixty per cent aggregates more than 0.84 mm. were slightly subjected to wind erosion.

Wind tunnel tests on soils with different texture showed that soil erodibility "Q", on a smooth surface and with wind velocity of five to six miles per hour at a height of one foot could be found from

THE FORMULA:

$$Q = \text{ANTILOG } \frac{(0.75C + 1.14D + 1.49E + 1.80F)}{C + D + E + F} - 0.5 \frac{B}{A + B} - 0.042\ (C + D + E + F)$$

Where in percentages A = erodible fraction smaller than 0.42 mm. in diameter; B = erodible fraction from 0.42 to 0.83 mm. in diameter; C = non-erodible fraction from 0.83 to 2.0 mm. in diameter; D = non-erodible fraction 2.0 to 6.4 mm. in diameter; E = non-erodible fraction 6.6 to 12.7 mm. in diameter; and F = non-erodible fraction more than 12.7 mm. in diameter. For greatly erodible soils Q is greater than one while for those of average erodibility Q is smaller than one. Those with Q smaller than 0.01 were very resistant to erosion.

Chepil (26), in order to get a representative way of assessing erodibility by wind, attempted to take into consideration some of the factors that mainly affect wind action. He expressed erodibility in terms of cloddiness, crop residue and roughness of the surface. The critical diameter, 0.84 mm., was again considered the dividing line between erodible and non-erodible fractions. The

SURFACE ROUGHNESS WAS FOUND TO DEPEND ON HEIGHT, DENSITY, QUALITY OF COVER, AND ON SIZE, SHAPE, AND LATERAL FREQUENCY OF CLODS AND RIDGES. AS IT WAS IMPOSSIBLE TO MEASURE ALL THESE FACTORS AND ESPECIALLY THE REACTION BETWEEN THEM, CHEPIL (OP. CIT.) DEVISED A RIDGE ROUGHNESS EQUIVALENT BASED ON THE HEIGHT OF RIDGES COMPOSED OF GRAVEL 2 TO 6.4 MM. IN DIAMETER AND HAVING A HEIGHT SPACING RATIO OF 1:4. A WIND TUNNEL WAS NECESSARY TO MAKE THE ESTIMATIONS AND THE FOLLOWING EQUATION WAS OBTAINED -

$$X = 491.3 \frac{I}{(RK)^{0.895}}$$

WHERE X = AMOUNT OF EROSION IN TONS/ACRE

I = SOIL ERODIBILITY INDEX BASED ON PERCENTAGE OF SURFACE MATERIAL GREATER THAN 0.84 MM. IN DIAMETER.

R = AMOUNT OF CROP RESIDUE IN POUNDS/ACRE

K = RIDGE ROUGHNESS EQUIVALENT IN INCHES

IT WAS FOUND THAT IF X IS SMALLER THAN 0.25 THE ERODIBILITY WAS INSIGNIFICANT, WHILE A VALUE FROM 0.25 TO 5.0 WAS CONSIDERED MODERATE AND THOSE VALUES MORE THAN 5.0 INDICATED A HIGH TO VERY HIGH ERODIBILITY.

Wet sieving and the determination of various water-stable soil aggregate groups has been used as another means for determining soil susceptibility to erosion. As mentioned before, both water-stable soil aggregates less than 0.05 mm. in diameter and those more than 0.50 mm. in diameter were very effective in reducing erodibility. The soils most subject to erosion contained a large quantity of intermediate size of water-stable soil aggregates between 0.05 and 0.48 mm. in diameter. Chepil (9) showed that when the content of water-stable soil aggregates 0.42 to 0.84 mm. in diameter increased from 0 to 12.1 per cent erodibility decreased by more than twice. Doubling this fraction greatly reduced the amount of erodible material while tripling caused a trivial reduction. The increase in the water-stable soil aggregates 2.0 to 0.83 mm. in diameter had a more profound effect on decreasing erodibility than the increase in the fractions of water-stable soil aggregates 0.48 to 0.83 mm. in diameter.

MATERIALS AND METHODS

ASSESSMENT OF METEOROLOGICAL DATA

In order to thoroughly examine the meteorological data with regard to wind at different stations in Alberta and to set a suitable programme for counteracting wind erosion three factors are considered: 1. wind speed and total wind mileages; 2. the prevailing direction; and 3. the frequency of occurrence of erosive and non-erosive winds. The main stations compared are Edmonton, Calgary, Lethbridge, Medicine Hat, Red Deer, Lac La Biche, and Lacombe. Unfortunately data dealing with the three factors already mentioned are not available for all stations. On the other hand, in dealing with the frequency of occurrence of erosive and non-erosive winds data are available for other stations. These stations are Brooks, Grande Prairie, Rocky Mountain House, Vermilion, and Keg River.

It has been noticed from the meteoro-

logical records that the different stations measure wind at different heights from the ground and thus comparing them with regard to wind speeds is misleading. Moreover, wind erosion is a surface phenomenon and what we are interested in is the speed near the ground surface. Therefore the writer used the formula suggested by Sutton (47) in order to convert all wind speeds at all stations to the speed at one foot above the ground. This formula follows as:

$$\overline{U} = \overline{U} \left(\frac{Z}{Z_1} \right)^{1/7}$$

Where $\overline{U}$ = average wind speed at any height, Z (one foot for our purpose)

$\overline{U}_1$ = average wind speed at height Z_1 (height of the anemovane)

The Soils

Four soil types at four different areas in Alberta were selected: Drumheller clay from the Drumheller area, Lethbridge loam from the Lethbridge area, Antler loam from the Red Deer area and Peace Hills sandy loam from the Edmonton area. The four soil types lie in the chernozemic order under the orthic sub-group. Both Drumheller clay and Leth-

BRIDGE LOAM ARE IN THE DARK BROWN GREAT SOIL GROUP, WHILE ANTLER LOAM AND PEACE HILLS SANDY LOAM ARE IN THE BLACK GREAT SOIL GROUP.

FOR REPLICATION, SAMPLES WERE TAKEN FROM FOUR SOIL SITES IN EACH SOIL TYPE. THREE SAMPLES WERE TAKEN BY HORIZONS AT EACH SITE REPRESENTING 1. THE UPPER LAYER OF THE VIRGIN SOILS (AH)*; 2. THE (B) HORIZON OF THE VIRGIN SOILS; AND 3. THE UPPER LAYER OF THE CULTIVATED SOIL IN THE SAME VICINITY (AA)**. HENCE THE TOTAL NUMBER OF SAMPLES WAS FORTY-EIGHT.

FOLLOWING IS A BRIEF DESCRIPTION OF THE FOUR SOIL TYPES TAKEN FROM SOIL SURVEY REPORTS (46).

DRUMHELLER CLAY

AH :	0 - 4"	FAIRLY LOOSE, GRANULAR
AB :	4 - 6"	LARGE NUCIFORM
BTJ:	6 - 12"	BLOCKY, SOME VERTICAL CLEAVAGE
BT :	12 - 24"	LARGE BLOCKY TO MASSIVE, WAXY
CK :	AT 24"	MACROSTRUCTURE IS LARGE BLOCKY AND MESOSTRUCTURE IS NUCIFORM

FREE CARBONATE OCCURS AT ABOUT TWELVE TO EIGHTEEN INCHES FROM THE SURFACE.

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* THE TERM AH CORRESPONDS TO Ah IN SOIL SURVEY REPORTS

** THE TERM AA CORRESPONDS TO Aa IN SOIL SURVEY REPORTS

LETHBRIDGE LOAM TO SANDY LOAM

AH	:	0 - 4"	LOOSE TO WEAK PRISMATIC
BM1	:	4 - 10"	FIRM PRISMATIC
BM2	:	10 - 14"	FAIRLY FIRMPPRISMATIC
CK	:	AT 14" - TO 26"	VERY LITTLE STRUCTURE MEDIUM TO HEAVY LIME
C	:		SOME LIME AND OCCASIONALLY SOME SALTS
D	:		TILL - ALLUVIAL LACUSTRINE

ANTLER LOAM

AH1	:	0 - 7"	BLACK FRIABLE LOAM - LOOSE
AH2	:	7 - 12"	BLACK, FIRM, MILDLY COLUMNAR SHARP BREAK BETWEEN A AND B
BM1	:	12 - 22"	FIRM COLUMNAR
BM2	:	22 - 28"	
CK	:	AT FROM 24 - 30"	
C	:		PASKAPOO TILL

PEACE HILLS SANDY LOAM

AH	:	0 - 15"	BLACK TO GREY BLACK FINE SANDY LOAM, FRIABLE
AE	:	15 - 17"	LIGHT BROWN TO GREYISH DARK BROWN
BTJ	:	17 - 37"	HEAVY LOAM (SILTY)
CK	:	LOW TO MEDIUM $CaCO_3$ AT 37"	
C	:		LOAM TO SANDY LOAM

LEGAL LOCATIONS OF THE SITES SAMPLED ARE AS SHOWN IN TABLE 1.

TABLE 1

LOCATIONS

SOIL TYPE / LOCATION	DRUMHELLER CLAY	LETHBRIDGE LOAM	ANTLER LOAM	PEACE HILLS SANDY LOAM
1	NW$\frac{1}{4}$- 8-30-20-W4	SE$\frac{1}{4}$-31-10-23-W4	NE$\frac{1}{4}$-15-35-28-W4	SE$\frac{1}{4}$- 8-54-23-W4
2	NE$\frac{1}{4}$- 9-30-20-W4	NE$\frac{1}{4}$-30-10-23-W4	SE$\frac{1}{4}$-36-34-28-W4	NE$\frac{1}{4}$- 9-54-23-W4
3	SE$\frac{1}{4}$- 3-30-20-W4	NE$\frac{1}{4}$-30-10-23-W4	SW$\frac{1}{4}$-30-34-27-W4	SW$\frac{1}{4}$- 9-54-23-W4
4	NE$\frac{1}{4}$-11-30-20-W4	SE$\frac{1}{4}$-30-10-23-W4	SE$\frac{1}{4}$-29-34-27-W4	NE$\frac{1}{4}$-10-54-23-W4

TABLE 1 SHOWS THE DIFFERENT LOCATIONS OF THE SOIL SAMPLES COLLECTED.

All samples were sieved in the field or in the laboratory using a special 6 mm. sieve in order to get rid of stones, gravels and grasses. A pailful of each sample (30 pounds) was taken. Samples required for the wet sieving were taken without disturbance, placed in glass containers and carefully sealed to keep them at field moisture.

Methods of Physical Analysis

For the mechanical analysis soils were ground in a mechanical grinder to pass 2 mm. sieve. The mechanical analysis was carried out by the Pipette method as modified by Toogood and Peters (49). The non-erodible fraction larger than 0.84 mm. in diameter was determined by dry sieving method using a special cylindrical sieve described by Chepil (26). Wet sieving was done according to a method described by Yoder (54), and mean weight-diameter was determined graphically as suggested by Van Bavel (51).

Methods of Chemical Analysis

Samples required for the chemical analysis were first ground using mortar and pestle.

The organic matter total nitrogen and calcium carbonate equivalent were determined by the A.O.A.C. methods (41), and total phosphorus by the meta vanadate method (35).

Greenhouse Experiment

For the greenhouse experiment, soils were used directly without mixing with any foreign materials. Plastic pots six inches in diameter were used to avoid loss of moisture and fertilizers. The pots were filled on volume basis and up to one inch from the edge. Nitrogen and phosphorus fertilizers were added, each at three levels. Nitrogen was added as ammonium nitrate at the rate of zero, fifty, and one hundred pounds nitrogen per acre on an area basis and phosphorus was added as monocalcium phosphate at the rate of zero, forty, and eighty pounds of P_2O_5 per acre, in all possible combinations. Thus the result was nine fertilizer treatments and consequently the total number of pots used was (9 x 48) or 432 pots.

The phosphate fertilizer was placed one inch below the surface. To do this the surface one

inch was removed from the pot, the fertilizer spread and then put back in the pot. In order to achieve a fairly uniform and accurate distribution of the fertilizers, they were placed in solution form using an analytical burette.

Gateway barley, with one hundred per cent germination, was used. Sixteen seeds were placed in each pot in a uniform fashion. Nitrogen was added and the pots immediately watered. A week after germination the number of plants was thinned to twelve. The growing plants were supported by three strings circled around four bamboo sticks placed in each pot.

Planting was done on the fifteenth of August. The greenhouse temperature was thus fairly high during the growing period and no cooling device was available. Maximum temperature reached 92 degrees Fahrenheit and the minimum was 65 degrees Fahrenheit.

Watering with distilled water was done as and when necessary. Excess of water was completely avoided by adding it with great care so as not to reach the saturation point. Every pot was placed in an aluminum tray and in case of any leaching, the

LEACHATE WAS WASHED BACK FROM THE PLATE INTO THE POT.

THE PLANTS WERE EXPOSED TO ARTIFICIAL LIGHTS FOR SIX HOURS EACH NIGHT. HOWEVER THERE WAS NO GREAT NECESSITY FOR THIS SINCE ALL OUR INTEREST WAS FOCUSED ON THE GREEN GROWTH.

THE BASIC DESIGN OF THE EXPERIMENT WAS A SPLIT PLOT DESIGN.

PLANTS WERE HARVESTED WHEN THE HEADS BEGAN TO FORM. PLANTS WERE CUT AT THE SOIL SURFACE AND WERE PLACED IN PAPER BAGS. THE BAGS AND THEIR CONTENTS WERE OVEN-DRIED AT 105 DEGREES CENTIGRADE FOR TWO DAYS. THE NET WEIGHTS OF THE DRY PLANTS WERE RECORDED.

RESULTS AND DISCUSSION

METEOROLOGICAL STUDIES

Figure 1 presents the Department of Transport data for the monthly long term average wind mileages at seven stations: Lethbridge, Calgary, Edmonton, Medicine Hat, Red Deer, Lac La Biche, and Lacombe. In observing the figure it can be noted that Lethbridge has by far a higher mean monthly wind mileage than any other stations, while Lacombe has the lowest mean monthly wind mileages. Medicine Hat, Calgary, Edmonton, Red Deer and Lac La Biche occupy an intermediate position. Lethbridge has more than twice as much wind mileages as Lacombe. Calgary and Medicine Hat are about equal in wind mileage. It can also be noted that there is a general trend at all the stations towards an increase in wind mileages in the late winter and early spring with a peak reached in April. This is in fact very serious since the soils at this time

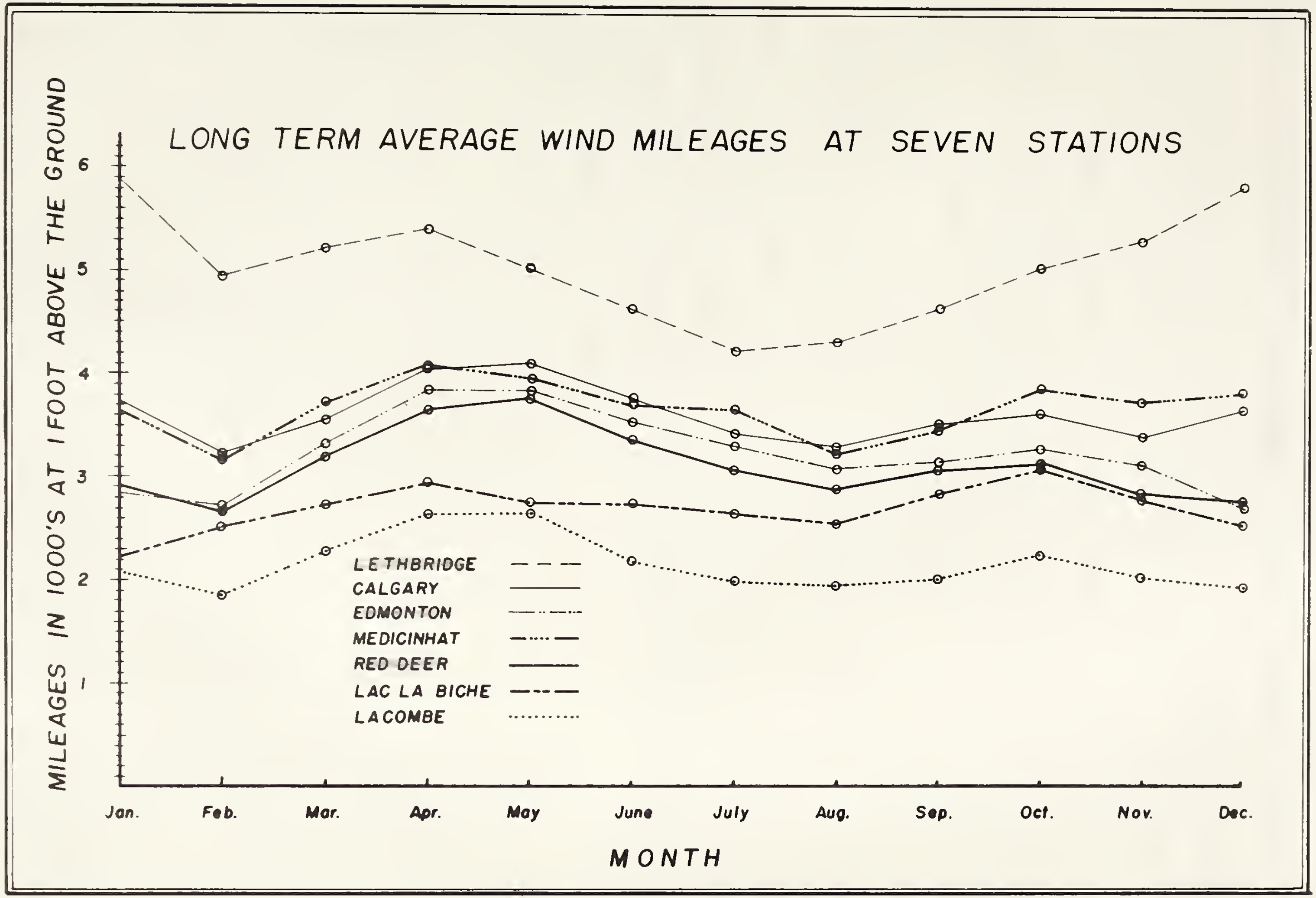

FIGURE 1: WIND MILEAGES AT SEVEN STATIONS IN ALBERTA CALCULATED AT ONE FOOT ABOVE THE GROUND ACCORDING TO SUTTON (47)

are often bare and dry and crops have not yet grown enough to protect the soil surface. After April the average mileages drop during the summer months and reach a minimum in July and August. Another rise in wind mileages occurs during the early autumn. However, this is not serious since the soils are mainly covered with crop residues or snow during this period. Note that the mileage at Lethbridge continues to rise and reaches the maximum for the year in December. Coupled with the fact that chinook winds often remove all snow cover at this time of the year this high wind mileage gives rise to a serious erosion hazard.

The writer would like to draw the attention to the apparently low wind mileages in the month of February. This is not in fact due to a low wind speed during this month. The wind mileages in any month is the product of the wind speed and the number of hours each month. The number of hours varies from 744 hours in January, for example, to 672 hours in February. Therefore the total mileages are deceptively small in the month of February.

A glance at Figure 2 will give the reader an idea about the frequency of occurrence of winds from different directions in percentages. This information is extremely important and should be considered before setting down a soil conservation programme. In the strip crop method, for example, the strips should be perpendicular to the prevailing direction of the wind. The prevailing direction at Lethbridge is from the west (28 per cent) and the south west (22 per cent). The prevailing direction is from the south at Edmonton (21 per cent), Red Deer (23 per cent), Lac La Biche (23 per cent), and Lacombe (30 per cent). At Medicine Hat the prevailing direction is from the south west (32 per cent). No strongly prevailing direction is noted for Calgary. Therefore the strips should be set from the east to the west in Edmonton, Red Deer, and Lacombe areas; from the north west to the south east at Medicine Hat; while at Lethbridge strips should be set in either of two directions - from north to south or from the north west to the south east. Two directions would also appear to be needed at Lac La Biche: from the east to the west or from the north east to south west. However, as will be pointed out below, at this

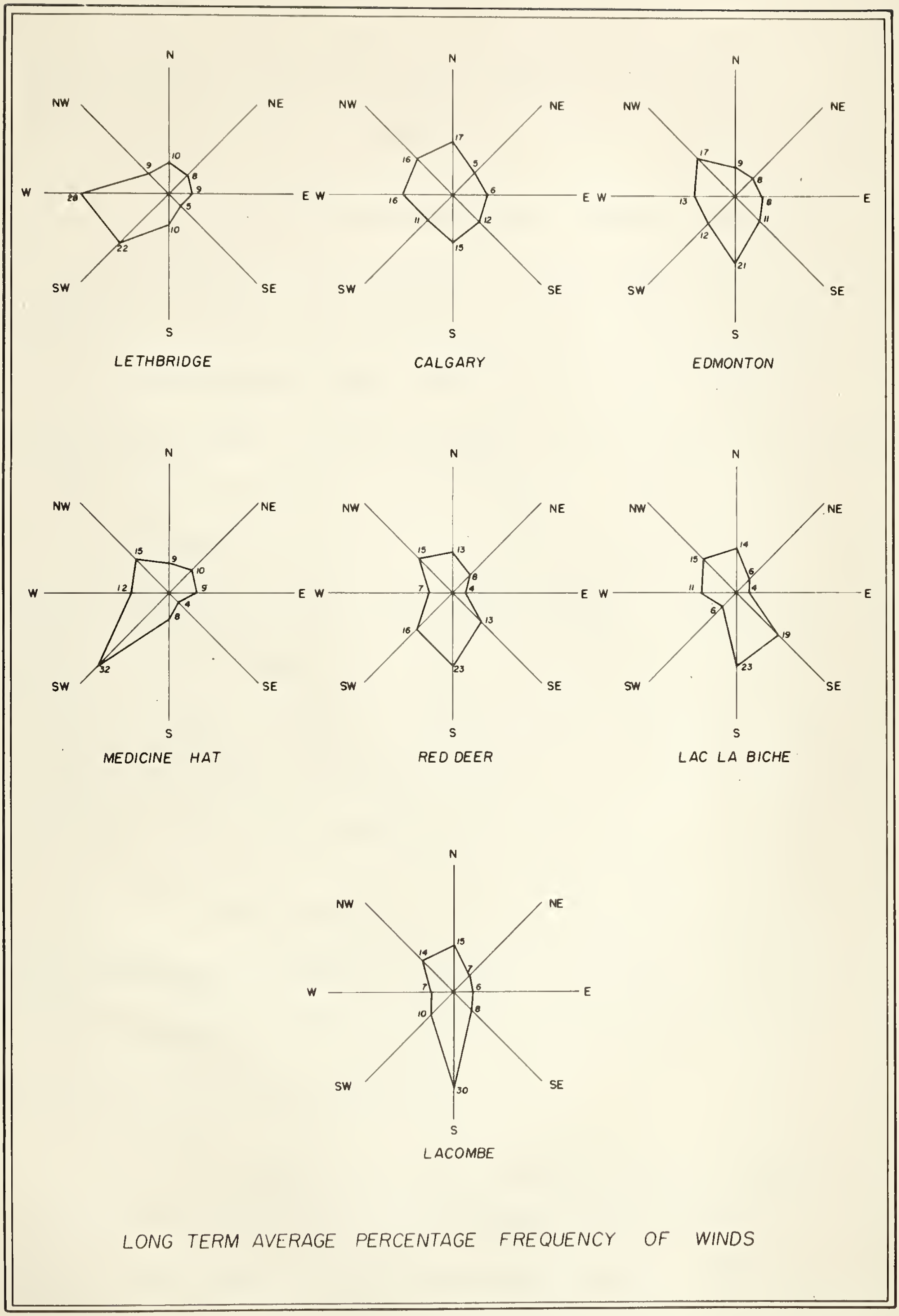
LETHBRIDGE
CALGARY
EDMONTON
MEDICINE HAT
RED DEER
LAC LA BICHE
LACOMBE
LONG TERM AVERAGE PERCENTAGE FREQUENCY OF WINDS

FIGURE 2

LATTER STATION EROSIVE WINDS SELDOM OCCUR AND GENERALLY NO STRIP CROPPING IS REQUIRED IN THE AREA.

TABLE 2 PRESENTS THE AVERAGE FREQUENCY OF DAILY MAXIMUM WIND SPEEDS AT TEN STATIONS IN THE PROVINCE. THE VALUES SHOWN ARE THE AVERAGE NUMBER OF DAYS EACH MONTH WHEN THE MAXIMUM WIND SPEEDS MAINTAINED OVER ONE HOUR PERIOD FALL WITHIN ANY ONE OF THE FIVE DIFFERENT SPEED GROUPS. ANNUAL VALUES ARE EXPRESSED AS FREQUENCY IN PERCENTAGE OF THE TOTAL NUMBER OF DAYS DURING THE YEAR. THE WRITER WOULD LIKE TO POINT OUT THAT THE DIFFERENT SPEED LIMITS OF WIND SHOWN IN THE SECOND COLUMN OF TABLE 2 ARE CALCULATED ACCORDING TO THE EQUATION SUGGESTED BY SUTTON (47) AND REFERRED TO EARLIER ON PAGE 24.

THE FREQUENCY OF OCCURRENCE OF EROSIVE AND NON-EROSIVE WINDS IS SHOWN IN FIGURE 3, CONSIDERING ALL WINDS OVER TEN MILES PER HOUR AT ONE FOOT ABOVE THE GROUND AS EROSIVE.

ON EXAMINING THE TABLES AND THE GRAPH, IT CAN BE NOTED THAT THE SOUTHERN STATIONS ARE EXPOSED TO WINDS OF VERY HIGH VELOCITIES. THIS IS ILLUSTRATED BY THE DATA FOR LETHBRIDGE, CALGARY,

TABLE 2

AVERAGE FREQUENCY OF DAILY MAXIMUM WIND SPEEDS IN DAYS

STATION	SPEED IN M.P.H. ONE FOOT ABOVE THE SURFACE	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	%
BROOKS	10 AND LESS	23	19	16	18	19	19	24	24	18	18	19	19	64
	11-13	5	5	10	8	7	7	5	5	8	6	6	6	21
	14-17	2	3	4	3	4	3	2	2	3	5	4	4	11
	18-21	1	1	1	1	1	1	0	0	1	1	1	1	3
	22 AND OVER	0	0	0	0	1	0	0	0	1	1	0	1	1
MEDICINE HAT	10	22	19	19	18	18	18	24	23	18	17	17	18	63
	11-13	7	6	7	8	10	9	4	6	8	7	8	6	24
	14-17	2	2	4	3	2	2	3	2	2	6	3	4	9
	18-21	0	1	1	1	1	1	0	0	2	1	2	3	4
	22 AND OVER	0	0	0	0	0	0	0	0	0	0	0	0	0
LETHBRIDGE	10	16	13	15	14	13	13	20	19	13	10	12	10	46
	11-13	3	4	5	6	10	9	6	6	8	8	4	3	20
	14-17	5	5	5	5	5	5	4	6	5	7	6	5	17
	18-21	5	4	3	3	2	2	1	0	3	4	4	8	11
	22 AND OVER	2	2	3	2	1	1	0	0	1	2	4	5	5
CALGARY	10	16	15	16	12	12	12	16	19	15	12	15	12	47
	11-13	8	7	8	12	9	11	9	9	7	8	5	6	28
	14-17	5	4	5	5	7	5	5	3	5	7	7	8	18
	18-21	2	2	1	1	2	2	1	0	2	3	3	4	6
	22 AND OVER	0	0	0	0	1	0	0	0	1	1	0	1	1
GRANDE PRAIRIE	10	29	26	30	27	25	29	28	29	27	26	27	29	91
	11-13	2	2	1	2	6	1	3	2	2	4	3	2	8
	14-17	0	0	0	1	0	0	0	0	1	1	0	0	1
	18-21	0	0	0	0	0	0	0	0	0	0	0	0	0
	22 AND OVER	0	0	0	0	0	0	0	0	0	0	0	0	0

TABLE 2 (CONT'D)

STATION	SPEED IN M.P.H. ONE FOOT ABOVE THE SURFACE	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	%
	10 AND LESS	28	24	24	23	16	19	24	25	21	21	24	26	75
	11-13	2	3	5	5	10	9	5	5	6	6	5	3	18
EDMONTON	14-17	1	1	2	2	4	2	2	1	3	4	1	1	1
	18-21	0	0	0	0	1	0	0	0	0	0	0	1	6
	22 AND OVER	0	0	0	0	0	0	0	0	0	0	0	0	0
	10	29	26	30	28	29	28	30	30	29	30	28	28	95
	11-13	2	2	1	2	2	2	1	1	1	1	2	3	5
ROCKY MOUNTAIN HOUSE	14-17	0	0	0	0	0	0	0	0	0	0	0	0	0
	18-21	0	0	0	0	0	0	0	0	0	0	0	0	0
	22 AND OVER	0	0	0	0	0	0	0	0	0	0	0	0	0
	10	27	22	27	24	20	23	28	27	22	24	26	26	81
	11-13	3	5	3	4	8	6	3	3	8	6	3	4	15
VERMILION	14-17	1	1	1	2	3	0	0	1	0	1	1	1	4
	18-21	0	0	0	0	0	0	0	0	0	0	0	0	0
	22 AND OVER	0	0	0	0	0	0	0	0	0	0	0	0	0
	10	28	25	28	27	25	26	29	30	26	23	25	26	87
	11-13	2	3	2	2	5	3	1	1	3	6	2	3	9
LAC LA BICHE	14-17	1	0	1	1	1	1	1	0	1	2	2	1	3
	18-21	0	0	0	0	0	0	0	0	0	0	2	1	1
	22 AND OVER	0	0	0	0	0	0	0	0	0	0	0	0	0
	10	28	24	27	25	24	28	29	29	25	24	25	27	86
	11-13	2	4	3	4	5	2	2	2	4	5	4	2	11
KEG RIVER	14-17	1	0	1	1	2	0	0	0	1	2	1	1	3
	18-21	0	0	0	0	0	0	0	0	0	0	0	1	0
	22 AND OVER	0	0	0	0	0	0	0	0	0	0	0	0	0

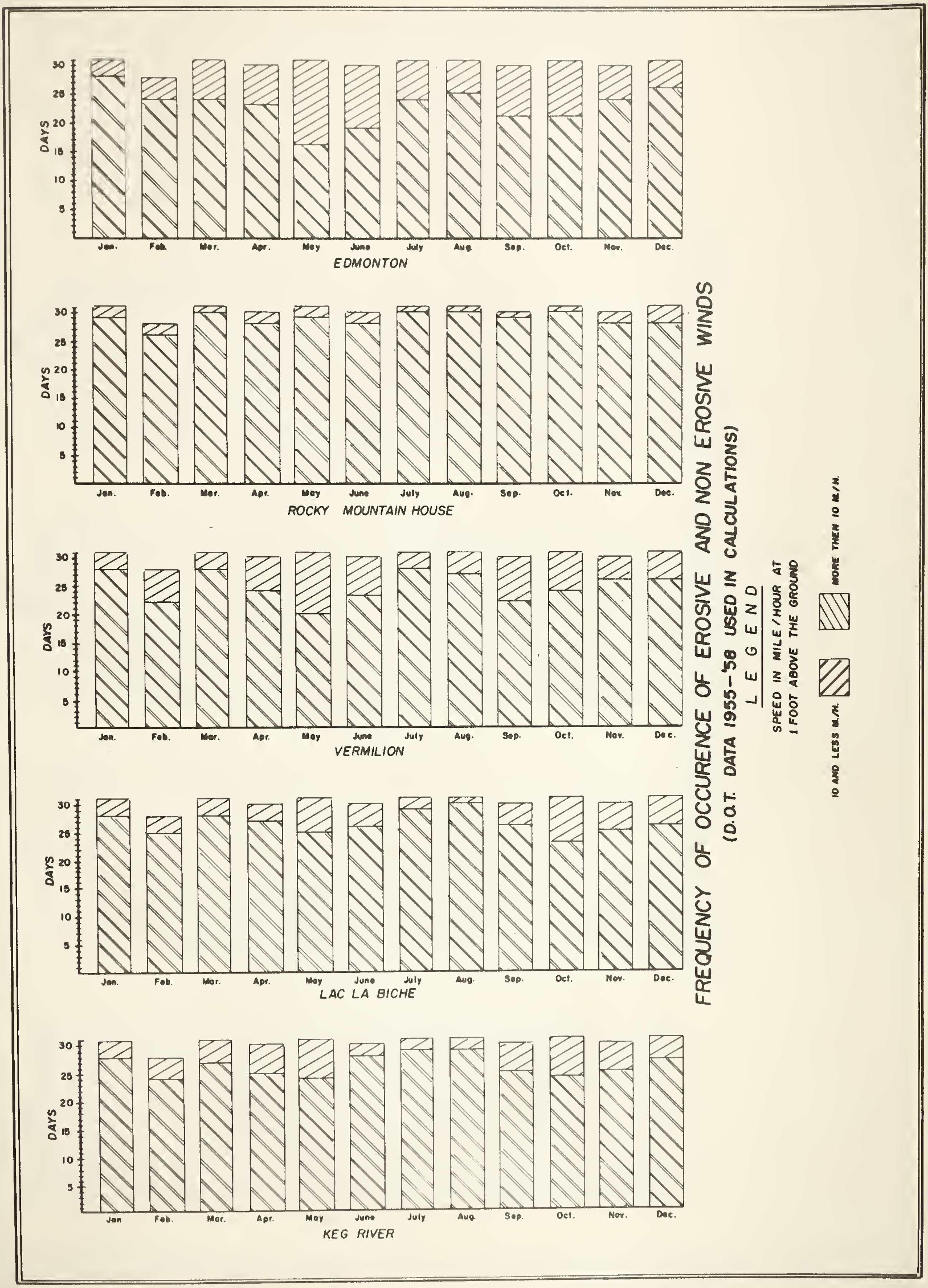
FREQUENCY OF OCCURENCE OF EROSIVE AND NON EROSIVE WINDS
(D.O.T. DATA 1955–'58 USED IN CALCULATIONS)
LEGEND
SPEED IN MILE / HOUR AT
1 FOOT ABOVE THE GROUND
10 AND LESS M./H.
MORE THEN 10 M./H.
DAYS
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sep.
Oct.
Nov.
Dec.
EDMONTON
ROCKY MOUNTAIN HOUSE
VERMILION
LAC LA BICHE
KEG RIVER

Figure 3

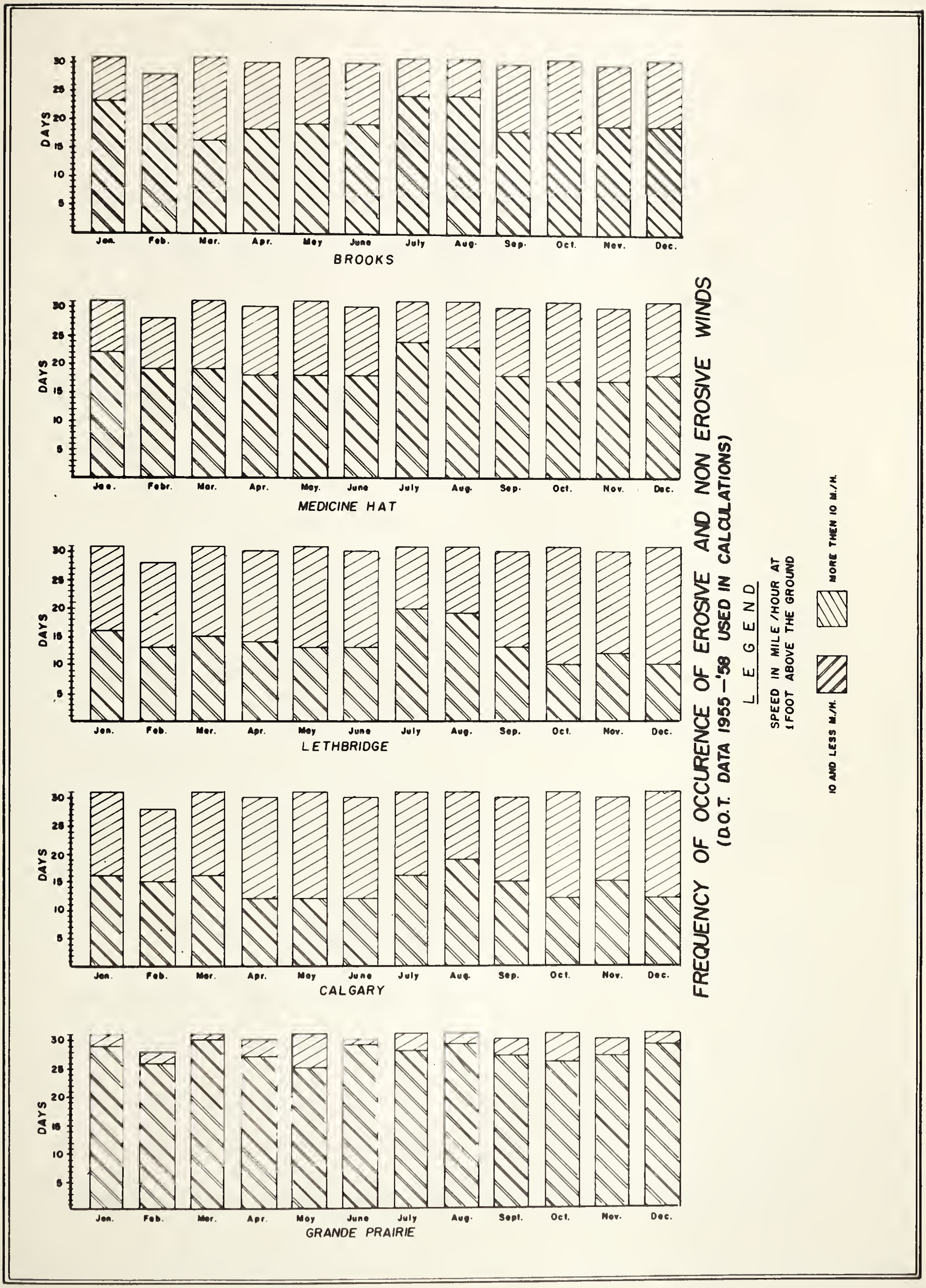

Figure 3 (cont'd)

Medicine Hat and Brooks. As we go northward there is a trend towards a decrease in the frequency of occurrence of highly erosive winds. Thus Edmonton and Vermilion are in an intermediate position. Erosive winds are quite rare in the northern areas of Lac La Biche, Grande Prairie and Keg River. The Rocky Mountain House area, though in the central area of the province is exposed to low wind speeds.

The frequency of occurrence of erosive winds during the late winter and early spring is very obvious at Calgary and Lethbridge. The erosive winds dominate more than fifty per cent of the time. Medicine Hat and Brooks follow. The Lethbridge station is unique in that it is exposed to more winds of extremely high speeds than the other stations.

In concluding this section of wind studies, it is quite obvious how serious actually is the wind action in the southern portion of the province. The total mileages as well as the frequency of occurrence of erosive winds are quite high. In addition the low precipitation, the lack of snow cover,

AND LONG DROUGHT PERIODS PUT THE SOILS OF THIS AREA IN A VERY CRITICAL POSITION. THE MIDDLE DISTRICTS OF THE PROVINCE (E.G. EDMONTON) ARE SOMEWHAT THREATENED BY EROSIVE WINDS. HOWEVER, THE RELATIVELY HIGH PRECIPITATION COUNTERACTS WIND EROSIVENESS.

CHEMICAL ANALYSIS

The Organic Matter and Total Nitrogen

The per cent variation in the organic matter and total nitrogen content in both the cultivated and the B horizon soil samples are shown in Tables 3 and 4 respectively. The Ah horizon of the virgin soil is used as the basis for comparison. In Figures 4 and 6 are presented the per cent organic matter and total nitrogen of all soil samples arranged according to soil types. The averages are shown in Figures 5 and 7. Statistical analyses are summarized in Table 5.

In examining the tables and the figures it can be observed that the cultivated soils sampled in the Drumheller area vary in their organic matter content from a loss of 18 per cent to an increase of 30 per cent, with an average decrease of 0.38 per cent when compared with adjacent virgin soils. The total nitrogen varies from a loss of 44 per cent to an increase of 19 per cent, with an average loss of 15 per cent. The B horizon samples show a consistent decrease in organic matter and total nitrogen,

TABLE 3

COMPARISON OF AA AND B HORIZONS WITH AH HORIZONS IN ORGANIC MATTER CONTENT

SOIL TYPE & HORIZON		PERCENTAGE DIFFERENCE				
		PROFILE NO.1	PROFILE NO.2	PROFILE NO.3	PROFILE NO.4	AVERAGE
DRUMHELLER CLAY	AH	——	——	——	——	——
	AA	-9.7 *	-18	+30.	+11	-0.38
	B	-38	-22	-17	-41	-35
LETHBRIDGE LOAM	AH	——	——	——	——	——
	AA	-24	-28	-2.6	-9.3	-8.6
	B	+5.2	+20.0	-9.3	-18	-2.9
ANTLER LOAM	AH	——	——	——	——	——
	AA	-0.25	-11	-33	-70.	-32
	B	-84	-77	-87	-80.	-82
PEACE HILLS SANDY LOAM	AH	——	——	——	——	——
	AA	+27	+50.	+25	+5.3	+24
	B	-96	-82	-85	-74	-86

* ALL DIFFERENCES ARE CALCULATED WITH RESPECT TO THE VIRGIN SOILS.

TABLE 4

COMPARISON OF AA AND B HORIZONS WITH AH HORIZONS IN TOTAL NITROGEN CONTENT

SOIL TYPE & HORIZON		PROFILE NO.1	PROFILE NO.2	PROFILE NO.3	PROFILE NO.4	AVERAGE
DRUMHELLER CLAY	AH	—	—	—	—	—
	AA	-44*	-8.8	+19	+2.7	-15
	B	-47	-32	-15	-41	-43
LETHBRIDGE LOAM	AH	—	—	—	—	—
	AA	-20	-39	0.00	10.0	-9.5
	B	+10.	+4.3	-33	+15	0.00
ANTLER LOAM	AH	—	—	—	—	—
	AA	-9.0	-6.3	-24	-54	-24
	B	-75	-68	-74	-62	-69
PEACE HILLS SANDY LOAM	AH	—	—	—	—	—
	AA	+50.	+47	+23	-10.0	+20.
	B	-81	-47	-64	-72	-70.

* ALL DIFFERENCES ARE CALCULATED WITH RESPECT TO THE VIRGIN SOILS.

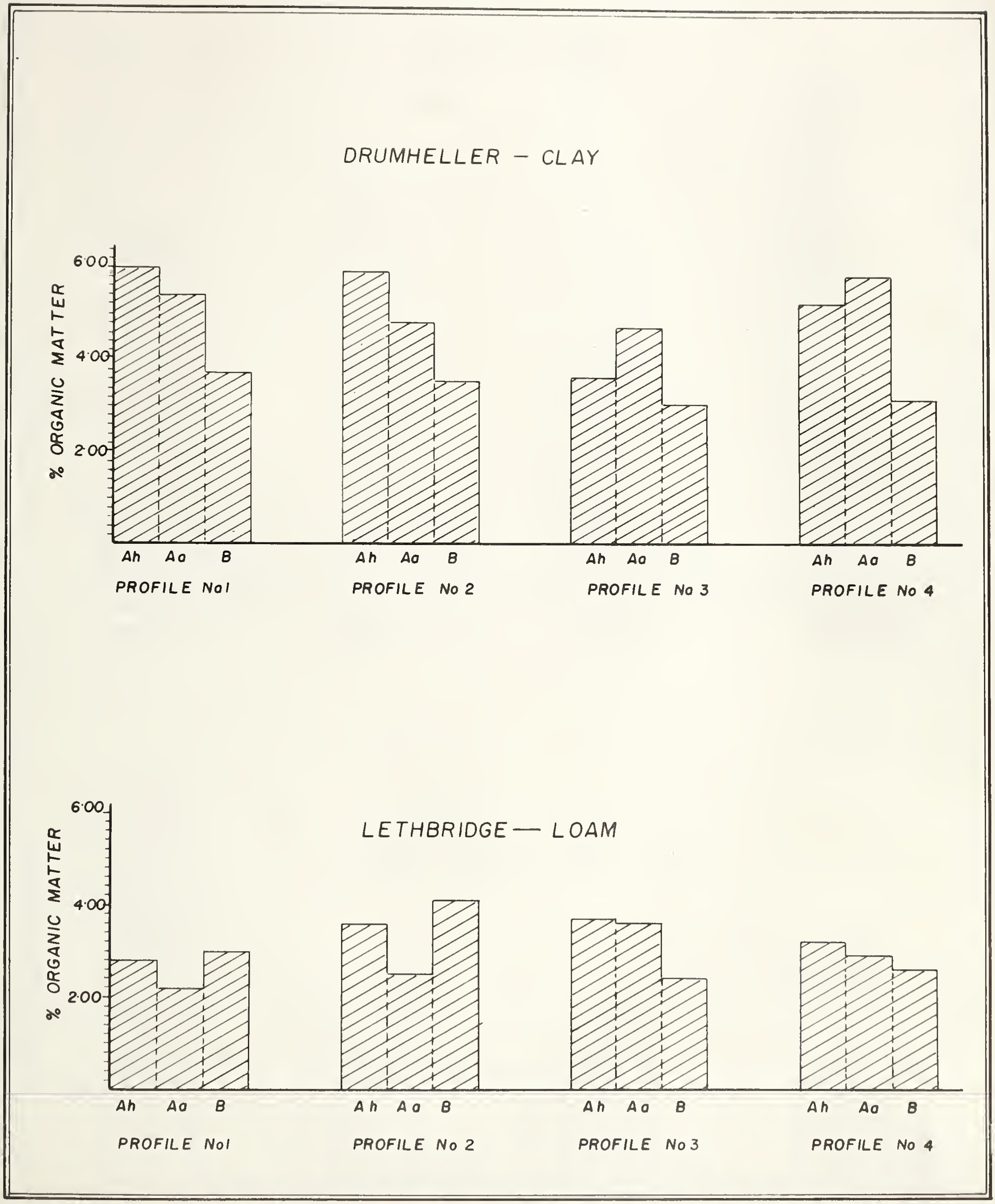

FIGURE 4: ORGANIC MATTER CONTENT OF SOILS

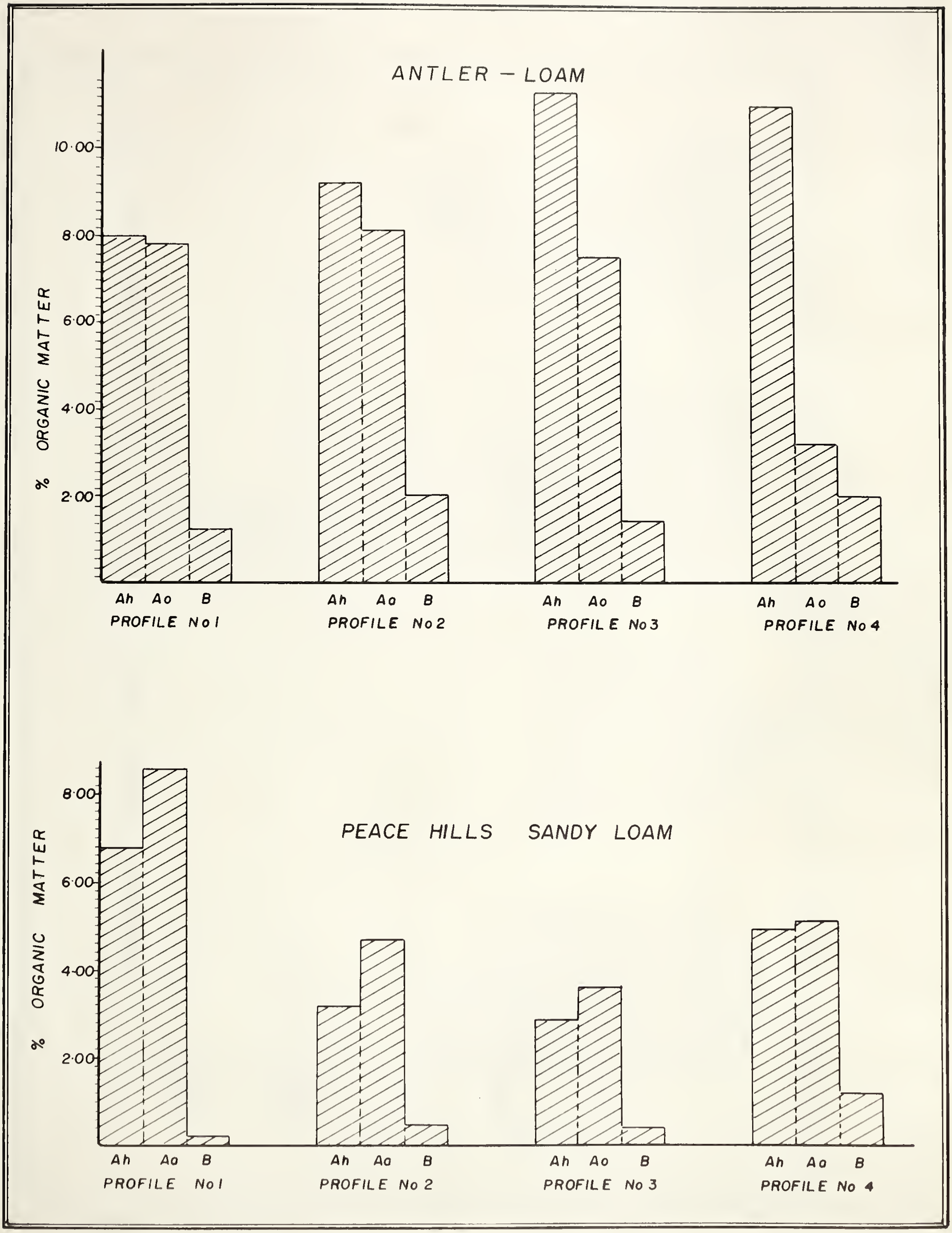

FIGURE 4 (CONT'D)

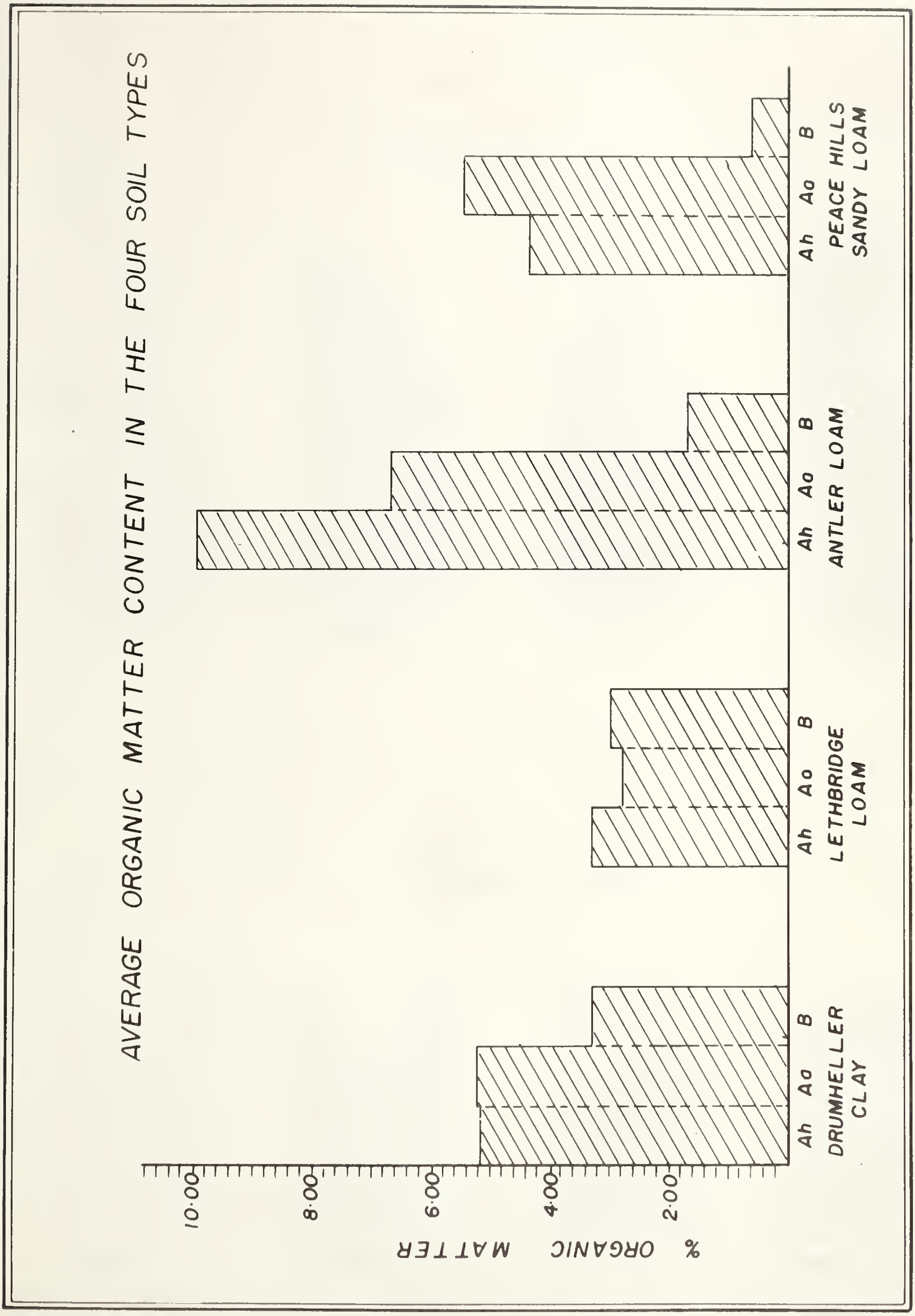

FIGURE 5: ORGANIC MATTER CONTENT OF SOILS

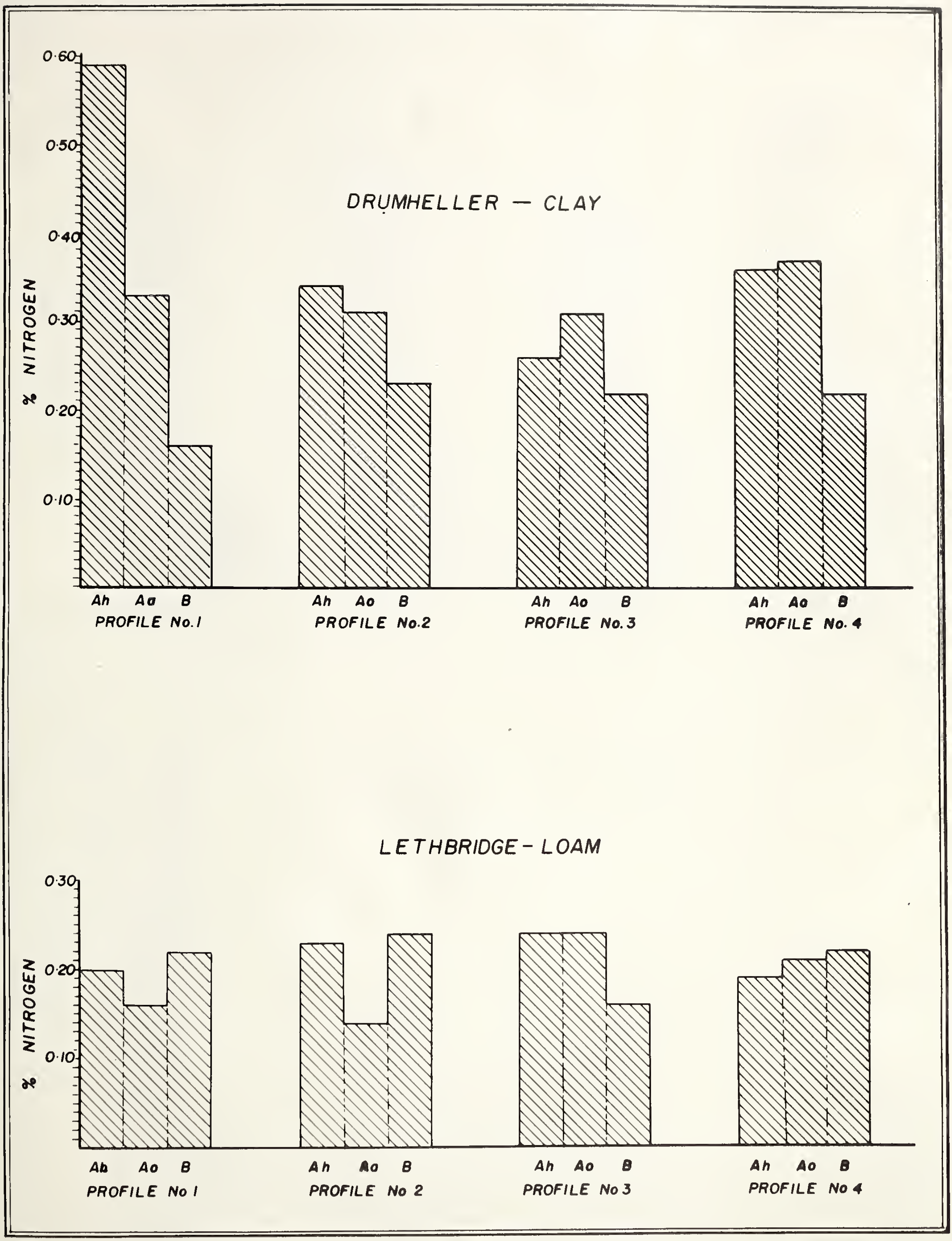

FIGURE 6: TOTAL NITROGEN CONTENT OF SOIL SAMPLES

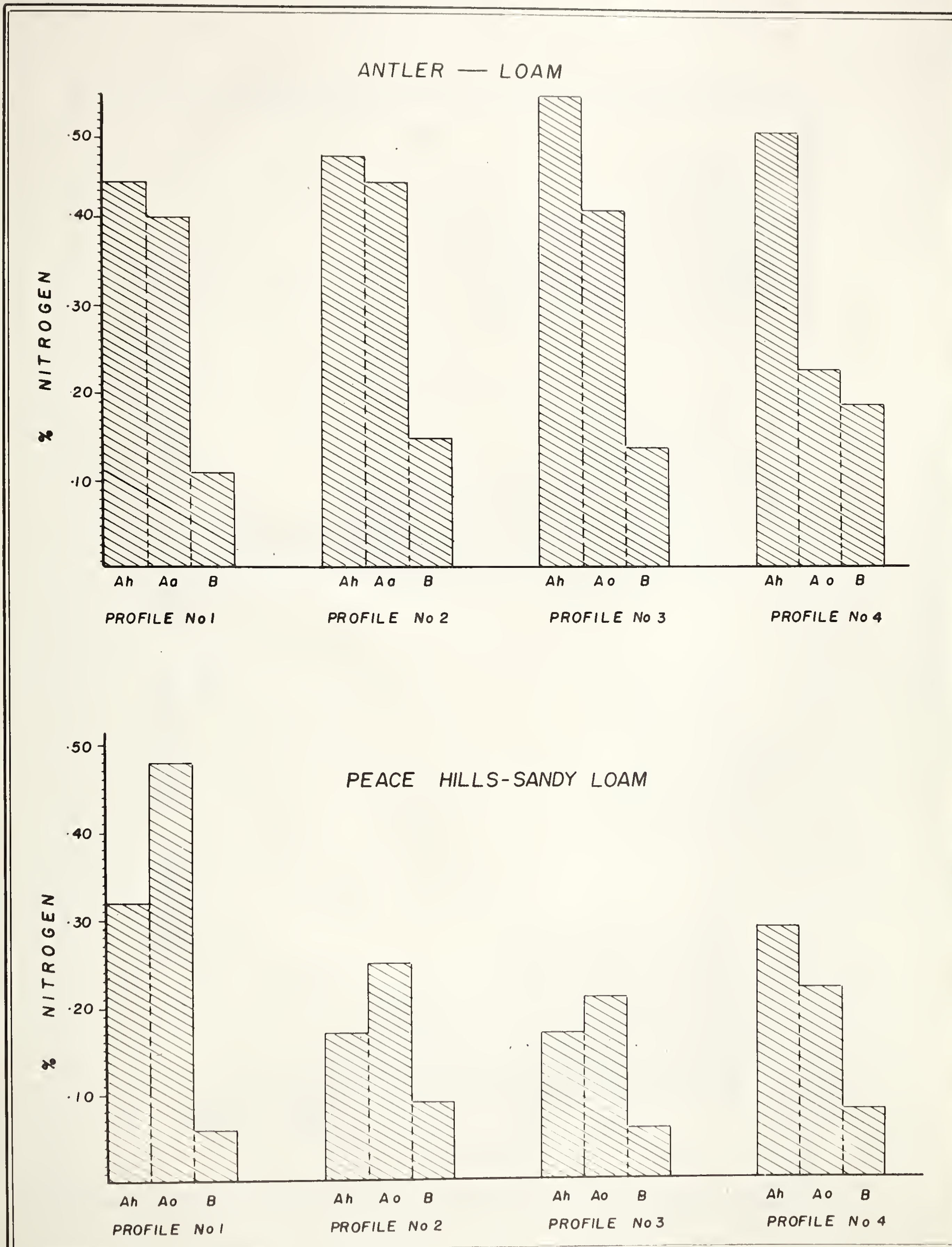

FIGURE 6 (CONT'D)

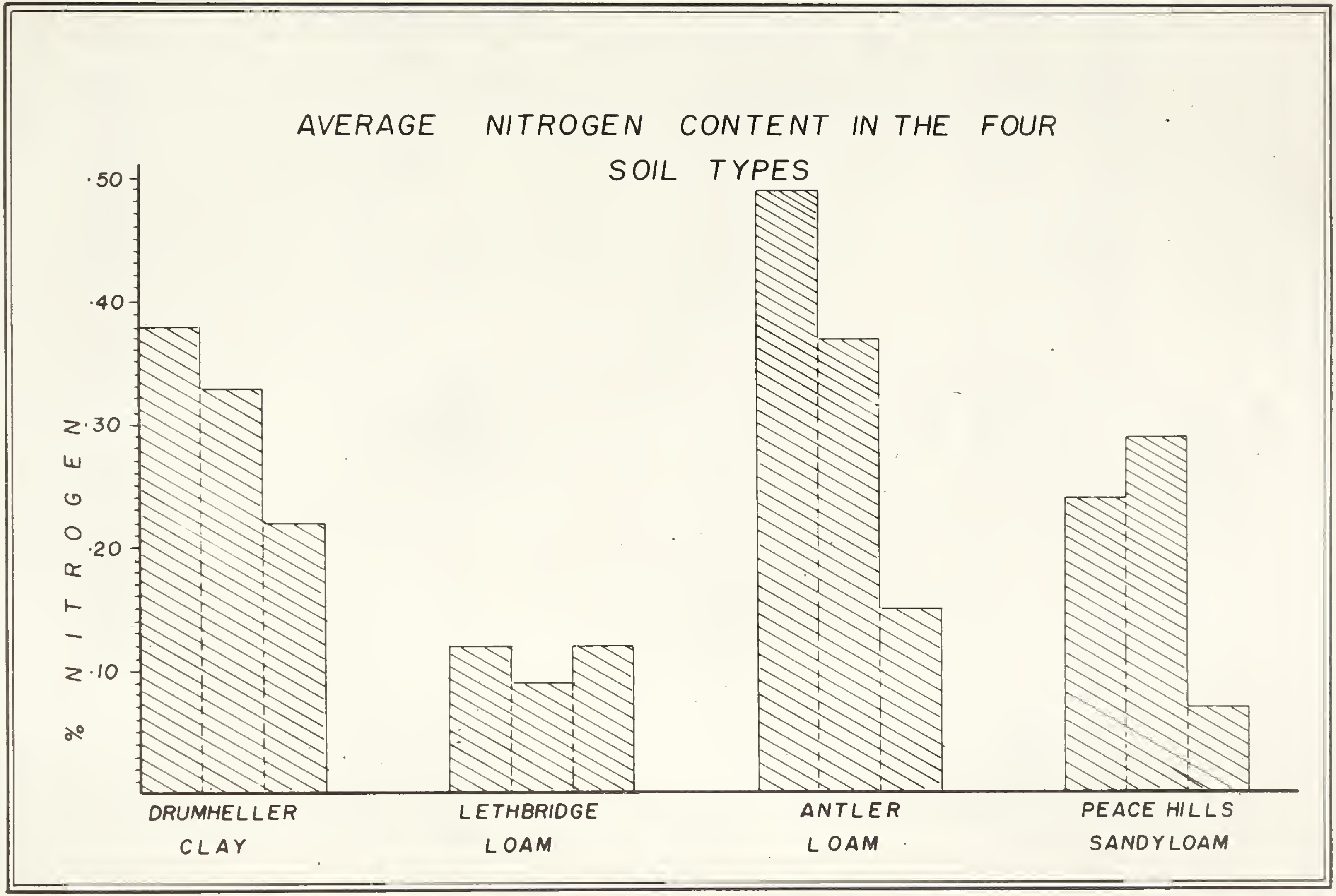

FIGURE 7: AVERAGE NITROGEN CONTENT OF SOILS

TABLE 5

SUMMARY OF THE ANALYSIS OF VARIANCE OF BOTH THE ORGANIC MATTER AND TOTAL NITROGEN SHOWING THE F-VALUES

SOURCE OF VARIATION	ORGANIC MATTER	TOTAL NITROGEN
SOIL TYPE	10**	12**
REPLICATES	0.55	1.0
HORIZONS	4.1*	5.3*
HORIZONS x TYPES	10**	5.1**

L.S.D. -

	ORGANIC MATTER	TOTAL NITROGEN
SOIL TYPES	1.31	0.06
SOIL HORIZON	1.72	0.07

** SIGNIFICANT AT ONE PER CENT LEVEL
* SIGNIFICANT AT FIVE PER CENT LEVEL

the decrease in the organic matter varying from 22 to 41 per cent, with the average of 35 per cent. On the other hand the decrease in total nitrogen varies from 15 per cent to 47 per cent, with an average decrease of 43 per cent. Statistical analyses indicate no significant differences between the cultivated and the virgin soils in their organic matter and total nitrogen. The B horizon, is significantly lower in these two constituents than both the Ah and the Aa horizons.

It is, therefore, apparent that wind erosion and cultivation have not seriously damaged the soils of the Drumheller area. However it must be borne in mind that Drumheller clay is a fine-textured soil type and that massive, rather than selective wind erosion frequently occurs. Thus we cannot expect great variations in the composition of Ah and Aa soil horizons. On the other hand the B horizon which will eventually come to the surface with continuous erosion contains on the average about one-third less organic matter and one-half less nitrogen than the virgin soil. The exposure of this horizon however, is not likely to occur in

the near future because of the fine texture of the Drumheller clay.

In the second soil type, Lethbridge loam, organic matter losses from the Aa horizon vary from 2.6 to 28 per cent, with an average of 8.6 per cent. The total nitrogen varies from a loss of 39 per cent to an increase of ten per cent with an average loss of 9.5 per cent. The organic matter content of the B horizon varies from a decrease of 18 per cent to an increase of 20 per cent with an average decrease of 2.9 per cent. The total nitrogen varies from a decrease of 33 per cent to an increase of 15 per cent, with an average equal to that of the Ah horizon. Statistical analyses do not reveal any significant difference among the three horizons under investigation in their organic matter and total nitrogen. However on the average the organic matter and total nitrogen are the lowest in the Aa horizon. The great losses are clear in profiles no. 1 and 2, where the Aa horizon organic matter and total nitrogen are lower than those in the B horizon. This indicates that some of the cultivated soils in the Lethbridge area have

been seriously damaged by wind erosion and that perhaps they have lost all the upper layer and much of the B horizon. This conclusion is supported by data to be presented later.

The cultivated soils in the third soil type, Antler loam, are consistently lower in their organic matter and total nitrogen content than the virgin soils. The organic matter losses vary from 0.25 to 70 per cent, with an average loss of 32 per cent. Losses in total nitrogen vary from 6.3 to 54 per cent, with an average loss of 24 per cent. The organic matter decrease in the B horizon varies 77 to 87 per cent, with an average decrease of 82 per cent. The decrease in nitrogen, on the other hand varies from 62 to 75 per cent, with an average of 69 per cent. Statistical analyses indicate that there is a significant difference among the three horizons with the Ah at the top followed by the Aa and the B horizon. Soil erosion and cultivation have caused the loss of about one-third of the organic matter and one-fourth of the total nitrogen. The present high organic matter content of the Ah horizon in addition to its medium-texture

are factors that stimulate losses under the influence of erosive winds when these soils are brought under cultivation.

The cultivated soils in the Peace Hills sandy loam exhibit a different trend. They contain on the average more organic matter and total nitrogen than the virgin soils. The increase in organic matter varies from 5.3 to 50 per cent with an average of 24 per cent. The total nitrogen varies from a decrease of 10 to an increase of 50, with an average increase of 20 per cent. Greater reductions occur in the B horizon, where the organic matter varies from a decrease of 74 to 96 per cent, with an average decrease of 86 per cent, while the average loss in total nitrogen is 70 per cent. Statistical analysis indicates that the virgin and the cultivated soils are not significantly different from one another. On the other hand these two horizons are significantly higher in their organic matter and total nitrogen than the B horizon.

The higher organic matter and total nitrogen content in the Aa horizon as compared to

the Ah horizon in the Peace Hills soils are probably due to the great amount of crop residues present on the soil surface at the time of sampling and passing through the sieve when the samples were being prepared for analysis. However, the signs of wind erosion are not quite as clear as is the case with the southern regions of the province. This is no doubt a result of the moderate to slow wind speeds and more precipitation in the Edmonton area. However, under the influence of high wind speeds and long drought periods, soils in this area may be seriously affected since they are of coarse texture.

Total Phosphorus

In Table 6 data on the total phosphorus content of all soil samples are presented as well as the per cent variations of the Aa and the B horizons from the Ah horizon. Statistical analysis is summarized in Table 8.

In the Drumheller clay the Aa horizon phosphorus content varies from a loss of 2.7 to an increase of 9.6 per cent with an average increase of 2.8 per cent. The B horizon soil samples showed a consistent decrease in their phosphorus varying from

TABLE 6

COMPARISON OF TOTAL PHOSPHORUS CONTENT OF AA AND B HORIZONS WITH AH HORIZON

SOILS AND HORIZON		PROFILE NO. 1 PER CENT PHOSPHORUS	PROFILE NO. 1 DIFF. IN %	PROFILE NO. 2 PER CENT PHOSPHORUS	PROFILE NO. 2 DIFF. IN %	PROFILE NO. 3 PER CENT PHOSPHORUS	PROFILE NO. 3 DIFF. IN %	PROFILE NO. 4 PER CENT PHOSPHORUS	PROFILE NO. 4 DIFF. IN %	AVERAGE %	AVERAGE % DIFF.
DRUMHELLER CLAY	AH	0.068	______	0.073	______	0.062	______	0.075	______	0.069	______
	AA	0.068	0.0*	0.071	-2.7	0.068	+9.6	0.081	+8.0	0.071	+2.8
	B	0.064	-5.8	0.053	-27	0.062	0.0	0.064	-14	0.061	-12
LETHBRIDGE LOAM	AH	0.062	______	0.066	______	0.065	______	0.068	______	0.065	______
	AA	0.058	-6.4	0.061	-7.5	0.067	+3.0	0.071	+4.4	0.064	-1.5
	B	0.058	-6.4	0.040	-39	0.061	-6.1	0.067	-1.4	0.057	-12
ANTLER LOAM	AH	0.076	______	0.084	______	0.091	______	0.079	______	0.083	______
	AA	0.066	-1.3	0.089	+5.9	0.077	-15	0.048	-39	0.070	-15
	B	0.034	-42	0.037	-55	0.044	-51	0.038	-51	0.038	-54
PEACE HILLS SANDY LOAM	AH	0.065	______	0.042	______	0.042	______	0.073	______	0.056	______
	AA	0.076	+16	0.063	+50	0.048	+14	0.076	+4.1	0.066	+17
	B	0.034	-47	0.042	0.0	0.032	-23	0.073	0.0	0.045	-19

* ALL DIFFERENCES ARE CALCULATED WITH RESPECT TO THE VIRGIN SOILS.

5.8 to 27 per cent, with an average decrease of 12 per cent. The Aa horizon in Lethbridge samples vary in their phosphorus content from a loss of 7.5 to an increase of 4.4 per cent, with an average decrease of 1.5 per cent. The B horizon contains 1.4 per cent to 39 per cent less phosphorus, with an average decrease of 12 per cent.

The Aa horizons in the Antler loam show differences ranging from a gain of 5.9 to a loss of 39 per cent total phosphorus with an average loss of 15 per cent. The reduction in the B horizon varies from 42 to 55 per cent with an average of 54 per cent.

In the fourth soil type, Antler loam, the Aa is 4.1 per cent to 50 per cent higher in total phosphorus than the Ah, with an average increase of 17 per cent. The reduction in the B horizon varies from 0.0 per cent to 47 per cent, with an average decrease of 19 per cent.

Statistical analyses have not indicated any significant differences among the three horizons in any of the soil types. The only exception is the Antler loam where the B horizon is significantly lower in phosphorus than both the Ah and the Aa

horizon. Moreover there is no significant difference among the four soil types in their phosphorus content. Thus it can be concluded that wind erosion and cultivation have not significantly altered the total phosphorus content. However, further erosion undoubtedly will reduce the phosphorus content since the B horizon throughout the four soil types contains less total phosphorus than both Ah and Aa soil samples.

The Calcium Carbonate Equivalent

In Table 7 is recorded the calcium carbonate equivalent of all soil samples. Statistical analysis is summarized in Table 8. It can be noted from the table that in Drumheller clay the Ah horizon contains from 0.18 to 1.2 per cent calcium carbonate, with an average of 0.76 per cent. It varies in the Aa horizon from 0.32 to 0.60 per cent with an average of 0.47 per cent. On the other hand the variations in the B horizon are from 2.2 to 5.0 per cent, with an average of 3.7 per cent. The B horizon is significantly higher in its lime content than both Ah and Aa horizon. This is natural since the parent material is calcareous and the per cent

TABLE 7

COMPARISON OF CALCIUM CARBONATE EQUIVALENT FOR AA AND B HORIZONS WITH AH HORIZON

SOILS AND HORIZON		PROFILE NO. 1 % CAL. CARB. EQUIVALENT	DIFF. IN %	PROFILE NO. 2 % CAL. CARB. EQUIVALENT	DIFF. IN %	PROFILE NO. 3 % CAL. CARB. EQUIVALENT	DIFF. IN %	PROFILE NO. 4 % CAL. CARB. EQUIVALENT	DIFF. IN %	AVERAGE %	AVERAGE % DIFF
DRUMHELLER CLAY	AH	0.83	____	0.18	____	1.2	____	0.76	____	0.76	____
	AA	0.42	-49*	0.32	+77	0.60	-52	0.54	-28	0.47	-38
	B	5.0	+50 x 10	2.2	+1200	3.6	+180	4.1	+440	3.7	+40 x 10
LETHBRIDGE LOAM	AH	0.95	____	0.70	____	0.29	____	0.67	____	0.65	____
	AA	3.6	+280	4.0	+470	3.2	+990	5.3	+690	4.0	+50 x 10
	B	0.84	-11	0.72	+2.8	0.70	+140	0.63	-5.9	0.72	+11
ANTLER LOAM	AH	3.1	____	1.0	____	0.73	____	1.8	____	1.6	____
	AA	1.2	-60.0	1.0	0.0	0.73	0.0	0.43	-76	0.85	-49
	B	1.0	-34	0.93	-8.8	1.3	+90	0.53	-71	0.97	-42
PEACE HILLS SANDY LOAM	AH	0.74	____	0.30	____	1.4	____	0.83	____	0.82	____
	AA	0.62	-16	0.65	+120	0.64	-50.0	0.56	-32	0.62	-24
	B	0.44	-40.0	0.38	+26	0.62	-56	0.58	-30.0	0051	-37

* ALL DIFFERENCES ARE CALCULATED WITH RESPECT TO THE VIRGIN SOILS.

TABLE 8

SUMMARY OF THE ANALYSIS OF VARIANCE OF BOTH THE TOTAL PHOSPHORUS AND CALCIUM CARBONATE EQUIVALENT SHOWING THE F-VALUES

SOURCE OF VARIATION	TOTAL PHOSPHORUS	CALCIUM CARBONATE EQUIVALENT
SOIL TYPES	0.43	8.9**
REPLICATES	0.87	0.51
HORIZONS	27**	4.9*
HORIZONS X TYPES	6.9**	32**

L.S.D. -

	TOTAL PHOSPHORUS	CALCIUM CARBONATE EQUIVALENT
SOIL TYPES	----	0.56
SOIL HORIZON	0.01	0.76

** SIGNIFICANT AT ONE PER CENT LEVEL
* SIGNIFICANT AT FIVE PER CENT LEVEL

calcium carbonate increases downward in the soil profile.

The virgin soil samples of Lethbridge loam contain from 0.29 to 0.95 per cent lime with an average of 0.65 per cent. The cultivated soil, on the other hand contains from 3.1 to 5.3 per cent lime with an average of 4.0 per cent. The B horizon contains from 0.63 to 0.84 per cent lime with an average equal to 0.72 per cent. The exceedingly high calcium carbonate per cent in the Aa horizon indicates that these soils must have lost the upper layer and most of the B horizon since the B horizon soil samples, taken from the virgin soils, contain less calcium carbonate. This is in contrast to the Drumheller area where the B horizon is the highest among the three horizons in its lime content. Moreover there is a constant danger in the Lethbridge area from wind erosion since a close relationship exists between a soil's erodibility and its calcium carbonate content. Thus it can be expected that the removal of the upper layer from Drumheller soils, and the exposure of lime rich B horizon will aggravate wind erosion hazards in the Drumheller area in

the future.

The virgin soils in the Antler loam area contain from 0.73 to 3.1 per cent calcium carbonate, with an average of 1.6 per cent. The Aa horizon varies from 0.43 to 1.2 per cent with an average of 0.85 per cent. On the other hand the lime content in the B horizon ranges from 0.53 to 1.3 per cent, with an average of 0.97 per cent. The virgin soil contains on the average about twice as much lime as the cultivated soils.

In the Peace Hills area, the lime content of the virgin soils varies from 0.30 to 1.4 per cent with an average of 0.82 per cent. The range in the cultivated soils varies from 0.56 to 0.65 per cent with an average of 0.62 per cent. The B horizon is slightly lower, the lime content varying from 0.30 to 0.62 per cent, with an average of 0.51 per cent. No significant differences occur in the lime content of the three horizons.

In concluding this section of chemical analysis several points are noted:

1. The soils of the Lethbridge area not

only have been affected by erosion but also, they are continuously threatened as a result of their high lime content. The average organic matter content in the Lethbridge area is relatively small and any losses, no matter how small, can have serious consequences.

2. The apparently low erosion damage to the soils of Drumheller may be attributed to their fine texture. The exposure of the lime-rich B horizon will increase the chances for more soil erodibility.

3. Winds have not seriously affected the phosphorus content in the four soil types. The B horizon phosphorus content is slightly lower than either the Ah or the Aa horizons.

4. High organic matter content and medium texture, which are characteristics of the Antler loam soils, are two important factors in wind erosion. However, wind erosion does not appear to be a serious hazard in this area because of the high rainfall and the relatively low wind speeds.

PHYSICAL ANALYSIS

1. Mechanical Analysis

The textural relationships between the virgin, the cultivated, and the B horizon soil samples are shown in Table 9. The samples are grouped according to the soil type: the fine soils are placed first, followed by the medium and coarse textured soils.

Referring to the data on mechanical analysis it will be seen that in Drumheller clay, the virgin soils have a clay content of 76 to 80 per cent, a silt content of 17 to 22 per cent, and a sand content of 2 to 3 per cent. The cultivated soils, by comparison, have 61 to 78 per cent clay, 19 to 36 per cent silt and 3 to 4 per cent sand, while the B horizon samples have 71 to 82 per cent clay, 16 to 26 per cent silt and 2 to 3 per cent sand. Thus there is no wide variation in the mechanical composition of virgin and cultivated Drumheller soils. All the samples are placed in the heavy clay class. Profile number 2, however, exhibits more variations than the other profiles:

TABLE 9

MECHANICAL COMPOSITION OF SOILS

SOIL SERIES: DRUMHELLER

PROFILE NO.	HORIZON	% SAND	% SILT	% CLAY	TEXTURE
	AH	3	18	79	HEAVY CLAY
1	AA	3	21	76	HEAVY CLAY
	B	2	16	82	HEAVY CLAY
	AH	2	22	76	HEAVY CLAY
2	AA	3	36	61	HEAVY CLAY
	B	3	22	75	HEAVY CLAY
	AH	3	17	80	HEAVY CLAY
3	AA	3	19	78	HEAVY CLAY
	B	3	26	71	HEAVY CLAY
	AH	3	20	77	HEAVY CLAY
4	AA	4	26	70	HEAVY CLAY
	B	3	21	76	HEAVY CLAY

TABLE 9 (CONT'D)

SOIL SERIES: LETHBRIDGE

PROFILE NO.	HORIZON	% SAND	% SILT	% CLAY	TEXTURE
	AH	59	23	18	SANDY LOAM
1	AA	51	22	27	SANDY CLAY LOAM
	B	53	23	24	SANDY CLAY LOAM
	AH	45	21	34	CLAY LOAM-SANDY CLAY LOAM
2	AA	45	19	36	CLAY LOAM-SANDY CLAY LOAM
	B	46	22	28	CLAY LOAM-SANDY CLAY
	AH	45	26	29	CLAY LOAM-SANDY CLAY LOAM
3	AA	44	20	36	CLAY LOAM
	B	46	26	28	SANDY CLAY LOAM
	AH	56	25	19	SANDY LOAM
4	AA	46	18	36	SANDY LOAM
	B	51	22	27	SANDY CLAY LOAM

TABLE 9 (CONT'D)

SOIL SERIES: ANTLER

PROFILE NO.	HORIZON	% SAND	% SILT	% CLAY	TEXTURE
	AH	36	38	26	LOAM
1	AA	43	31	26	LOAM
	B	35	27	38	CLAY LOAM
	AH	25	37	38	CLAY LOAM
2	AA	30	37	33	CLAY LOAM
	B	27	48	25	LOAM - SILT LOAM
	AH	38	44	28	CLAY LOAM
3	AA	37	36	27	CLAY LOAM - LOAM
	B	31	50	19	SILT LOAM - LOAM
	AH	30	44	26	LOAM
4	AA	42	30	28	CLAY LOAM
	B	35	44	21	LOAM

TABLE 9 (CONT'D)

SOIL SERIES: PEACE HILLS

PROFILE NO.	HORIZON	% SAND	% SILT	% CLAY	TEXTURE
	AH	73	6	21	SANDY CLAY LOAM
1	AA	71	8	21	SANDY CLAY LOAM
	B	72	6	22	SANDY CLAY LOAM
	AH	75	5	20	SANDY CLAY LOAM SANDY LOAM
2	AA	80	7	13	SANDY LOAM
	B	77	3	20	SANDY CLAY LOAM SANDY LOAM
	AH	77	5	18	SANDY LOAM
3	AA	70	4	26	SANDY CLAY LOAM
	B	80	3	17	SANDY LOAM
	AH	81	5	14	SANDY LOAM
4	AA	70	5	25	SANDY CLAY LOAM
	B	78	4	18	SANDY LOAM

THE CULTIVATED SOIL CONTAINS 14 PER CENT LESS CLAY AND 15 PER CENT MORE SILT THAN THE AH HORIZON OF THE VIRGIN SOIL. THERE IS ALSO A GENERAL TREND IN THE CULTIVATED SOILS TOWARDS A SLIGHT INCREASE IN THE SILT AND A DECREASE IN THE CLAY CONTENT AS A RESULT OF CULTIVATION AND WIND EROSION.

FOR THE LETHBRIDGE LOAM SOILS, NONE OF WHICH ACTUALLY TEXTURES AS A LOAM, THE VIRGIN SOILS HAVE 18 TO 34 PER CENT CLAY, 21 TO 26 PER CENT SILT AND 45 TO 59 PER CENT SAND. THE CULTIVATED SOILS, BY COMPARISON, ARE ALWAYS HIGHER IN THE CLAY AND LOWER IN SAND AND SILT CONTENT. THEY HAVE FROM 27 TO 36 PER CENT CLAY, 18 TO 22 PER CENT SILT AND 45 TO 51 PER CENT SAND. ON THE OTHER HAND B HORIZON SOIL SAMPLES HAVE 24 TO 28 PER CENT CLAY, 22 TO 26 PER CENT SILT AND 46 TO 53 PER CENT SAND. A SHIFT TO A FINER TEXTURED SOIL APPEARS IN MOVING FROM THE VIRGIN AH HORIZON TO THE CULTIVATED AA.

IN THE CASE OF ANTLER LOAM, THE VIRGIN SOILS HAVE 26 TO 38 PER CENT CLAY, 37 TO 44 PER CENT SILT AND 25 TO 38 PER CENT SAND. THE CULTIVATED SOILS CONTAIN 26 TO 36 PER CENT CLAY, 30 TO 37 PER

cent silt and 30 to 43 per cent sand. The clay content in the two A horizons under investigation is about the same. There is a general trend towards an increase in sand and corresponding decrease in the silt content of the cultivated soils. The B horizon samples vary widely in their mechanical composition. They have 19 to 38 per cent clay, 27 to 50 per cent silt and 27 to 35 per cent sand. The B horizon is lower in clay and higher in silt than the virgin soils in three of the four profiles.

In the Peace Hills sandy loam soils the virgin soils have 14 to 21 per cent clay, 5 to 6 per cent silt and 73 to 81 per cent sand. The cultivated soils, in comparison, have 13 to 26 per cent clay, 4 to 8 per cent silt and 70 to 80 per cent sand. On the other hand, the B horizon soils have 17 to 22 per cent clay, 3 to 6 per cent silt and 72 to 80 per cent sand. The cultivated soils in both profile 3 and 4 are somewhat finer textured and are placed in the sandy clay loam class.

The differences in mechanical composition between the three horizons of the four soil types are summarized in Table 10.

This table indicates that the average mechanical composition of the virgin and the B horizon in the Drumheller area is almost identical. A small increase in the silt content and a corresponding decrease in the clay content are noted in the cultivated soils. The Aa horizon in the Lethbridge soils are higher in clay, and lower in silt and sand than the Ah horizon which suggests wind sorting. The Antler loams show a small increase in sand and corresponding decrease in silt resulting from cultivation and erosion. No such variations are noted for the Peace Hills soils.

It is obvious from the mechanical composition, that we cannot draw definite conclusions concerning wind erosion effects on these soils with the possible exception of the Lethbridge soils. The variations between the mechanical composition of the Ah and the Aa soils is very insignificant in the coarse textured Peace Hills soils. This is

TABLE 10

AVERAGE MECHANICAL COMPOSITION

SOIL TYPE	HORIZON	% SAND	% SILT	% CLAY	TEXTURE
DRUMHELLER CLAY	AH	3	19	78	HEAVY CLAY
	AA	3	26	71	HEAVY CLAY
	B	3	21	76	HEAVY CLAY
LETHBRIDGE LOAM	AH	51	24	25	SANDY CLAY LOAM
	AA	47	19	34	SANDY CLAY LOAM
	B	48-	32	20	LOAM
ANTLER LOAM	AH	32	29	39	CLAY LOAM
	AA	38	24	38	CLAY LOAM
	B	32	42	26	LOAM
PEACE HILLS SANDY LOAM	AH	77	5	18	SANDY LOAM
	AA	75	4	21	SANDY CLAY LOAM
	B	77	4	19	SANDY LOAM

because the soil under investigation is slightly exposed to erosive winds. The southern regions are lower in rainfall and higher in frequency of occurrence of erosive winds than the northern regions. The structural stability of soils as presented in the following section will give us a more reliable estimation of the degree of erosion hazard and resistance of the different soils to wind movement.

2. Mean Weight-Diameter

Figure 8 presents the mean weight-diameters in millimeters for all soil samples. The mean weight-diameter is an excellent index for measuring the degree of structural stability of soils. Each bar in the diagram is the average of three wet sievings.

Referring to the figure it will be seen that in the Drumheller clay the mean weight-diameter varies from 1.32 to 2.10 mm. in the virgin soils, from 0.73 to 1.49 mm. in the cultivated soils and from 1.32 to 1.80 mm. in the B horizon. The average mean weight-diameter for the Ah, Aa and B horizons

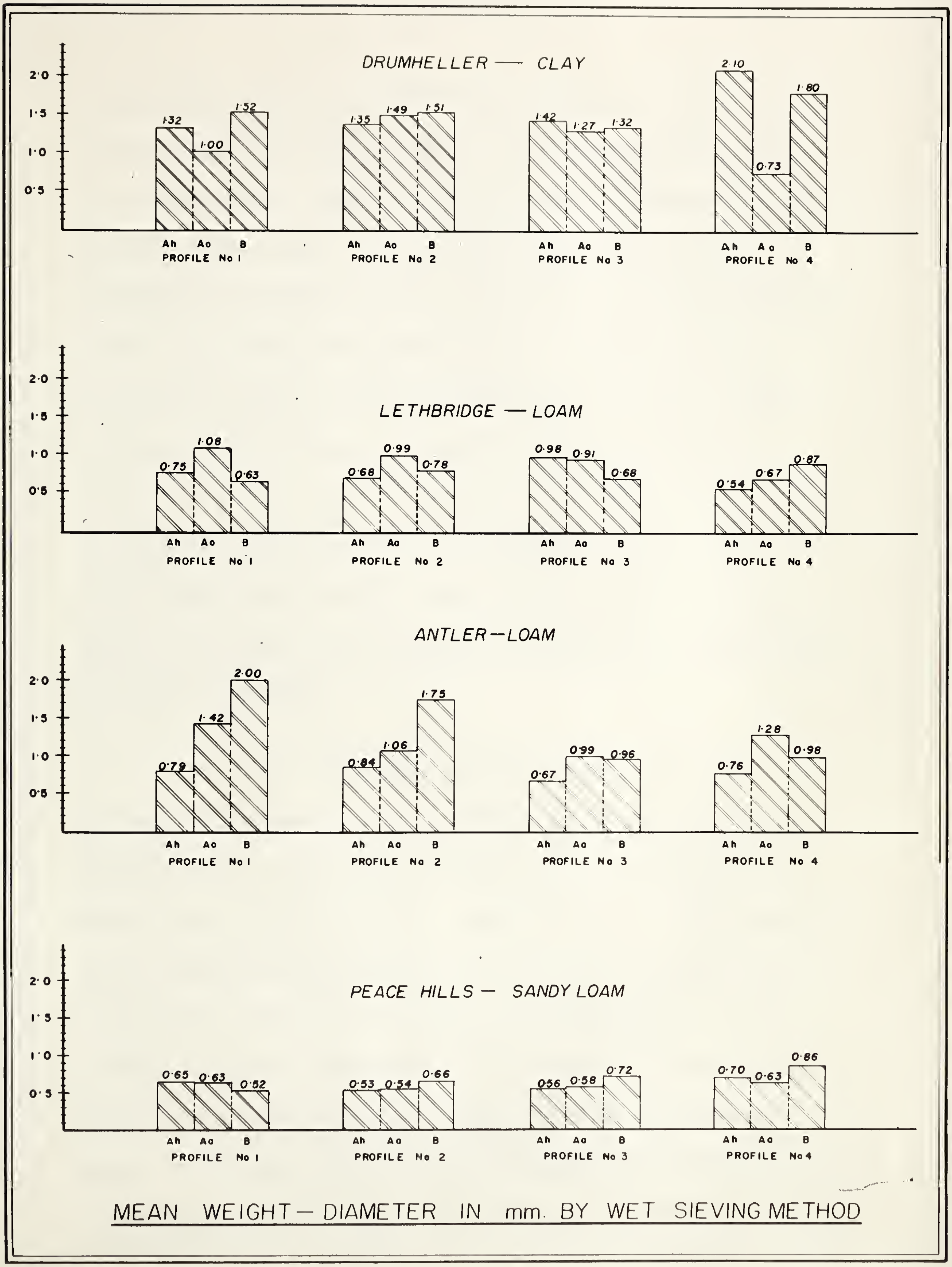

FIGURE 8: MEAN WEIGHT-DIAMETER AS DETERMINED BY WET SIEVING
SEE VAN BAVEL (51)

are 1.55, 1.12 and 1.55 respectively. Both Ah and B horizons are significantly higher in their mean weight-diameter than the Aa horizon. Therefore, it can be noted that cultivation and erosion have decreased the structural stability in the Drumheller clay. In fact this decrease in the structural stability can be mainly attributed to the disturbance of the original heavy clay by cultivation. However, it is also recalled from the previous discussion on the mechanical composition that the cultivated soils have less clay than the virgin soils, and this has probably resulted in lower mean weight-diameters.

For the Lethbridge soils, the mean weight-diameter is from 0.54 to 0.98 mm. in the virgin soils, 0.67 to 1.08 mm. in the cultivated soils and 0.63 to 0.87 in the B horizon. The average mean weight-diameters for the Ah, Aa and B horizons are 0.74, 0.91 and 0.74 mm. respectively. It is interesting to note that in three samples out of four the mean weight-diameter in the cultivated soil is higher than it is in the Ah horizon and that in another three cases out of four it is higher than

it is in the B horizons. This clearly indicates that the cultivated soils in the Lethbridge area are more resistant to erosive agents than the virgin soil. This has resulted from their continuous exposure to erosive winds and the removal of the most erodible fractions. However, the differences in the mean weight-diameter in the three horizons are not significant.

In the case of Antler loam, the virgin soil is consistently lower in its mean weight-diameter than both the Aa and B horizon soil samples. The mean weight-diameter is from 0.67 to 0.84 mm. in the virgin soil, 0.99 to 1.42 mm. in the cultivated soils and from 0.96 to 2.0 mm. in the B horizon. In other words the B horizon is the most resistant to erosion followed by the Aa and the Ah horizon, though these two horizons are slightly coarser in texture. This clearly indicates that the mean weight-diameter is not affected by soil texture alone. We recall from the chemical analysis that the organic matter is highest in the Ah followed by the Aa and B horizon. This high organic matter content greatly reduces the mechanical stab-

ility of structure, as found by Chepil and Moss (22, 39).

In the fourth soil type, the mean weight-diameter is 0.53 to 0.70 mm. in the Ah horizon, 0.54 to 0.63 mm. in the Aa horizon and 0.52 to 0.86 mm. in the B horizon. It is quite obvious that the differences among the three horizons are small and insignificant.

The differences in the mean weight-diameter in the three horizon in the four soil types are summarized in Table 11, while the analysis of variance is shown in Table 12.

TABLE 11

Average Mean Weight-Diameter in Millimeters

Soil type	Ah	Aa	B	Average
Drumheller clay	1.55	1.12	1.55	1.41
Lethbridge loam	0.740	0.910	0.740	0.790
Antler loam	0.760	1.19	1.42	0.840
Peace Hills sandy loam	0.610	0.590	0.690	0.630

TABLE 12

SUMMARY OF THE ANALYSIS OF VARIANCE OF THE MEAN WEIGHT-DIAMETER DATA

Source of Variation	F-value
Replicates	0.19
Types	10.0**
Horizons	0.79
Horizons x Types	5.6**

** Significant at one per cent level
L.S.D. (Types) = 0.267
L.S.D. (Horizons) = 0.339

It is noted from the above table that in both the Drumheller and Lethbridge soils the mechanical stability of structure in the virgin soils is equal to that of B horizon. However, the mean weight-diameter in the cultivated soils is higher in Lethbridge and lower in Drumheller. The organic matter role in affecting the mean weight-diameter in these two areas is in fact negligible since it is found in relatively small quantities. On the other hand, the increase in the structural stability in the Lethbridge area is undoubtedly due to its continuous exposure to winds, while the decrease in the structural stability of Drumheller clay is primarily due to the disturbances of the soil struc-

ture through cultivation and secondly through the small reduction in clay content. On the other hand the higher stability in the cultivated soil of the Antler loam is a result of the loss of organic matter. Finally the Peace Hills soil samples are generally the least resistant to erosion as a result of the high sand content.

Some workers have found a high correlation between the resistance of soils to erosion and both the fraction of water-stable soil aggregates more than 0.5 mm. and that smaller than 0.05 mm. However the finest sieve in this study has an opening of 0.125 mm. Correlation coefficients between the mean weight-diameter and both the water-stable aggregates greater than 0.50 and smaller than 0.12 mm. in diameter are shown in Table 13.

Thus it can be seen that there is a consistent positive correlation between the mean weight-diameter and the fraction of the water-stable soil aggregates greater than 0.50 mm. in diameter. On the other hand there is a negative correlation between the water-stable soil aggregates smaller than 0.125 and the mean weight-diameter with the

TABLE 13

COEFFICIENTS OF CORRELATION BETWEEN THE MEAN WEIGHT-DIAMETER AND BOTH WATER-STABLE SOIL AGGREGATES GREATER THAN 0.50 AND LESS THAN 0.125 MM.

TYPE	WATER-STABLE AGGREGATES GREATER THAN 0.5 MM.	WATER-STABLE AGGREGATES SMALLER THAN 0.12 MM.
DRUMHELLER CLAY	+0.84*	-0.13
LETHBRIDGE LOAM	+0.45	+0.31
ANTLER LOAM	+0.92	-0.88
PEACE HILLS SANDY LOAM	+0.84	-0.62

* R-VALUES

exception of Lethbridge soil. A highly significant negative correlation is noted in Antler while a low positive correlation is noted in the Lethbridge. It can thus be concluded that the mean weight-diameter is greatly affected by the amount of water-stable soil aggregates greater than 0.50 mm. in diameter.

3. Determination of the Erodible Fraction

"Erodible fraction" is defined here as being smaller than 0.84 mm. in diameter. Figure 9 shows the per cent erodible fraction as determined by dry sieving.

In the Drumheller soils, the erodible fraction is 20 to 27 per cent in Ah, 20 to 44 per cent in the Aa and 17 to 33 per cent in the B horizon. Thus it is noted that the cultivated soils are more susceptible to wind erosion. This is in agreement with our results of the mechanical composition and mean weight-diameter.

As for the Lethbridge soils, the erodible fraction is 48 to 61 per cent in the Ah horizon, 27 to 70 per cent in the Aa horizon and 54 to

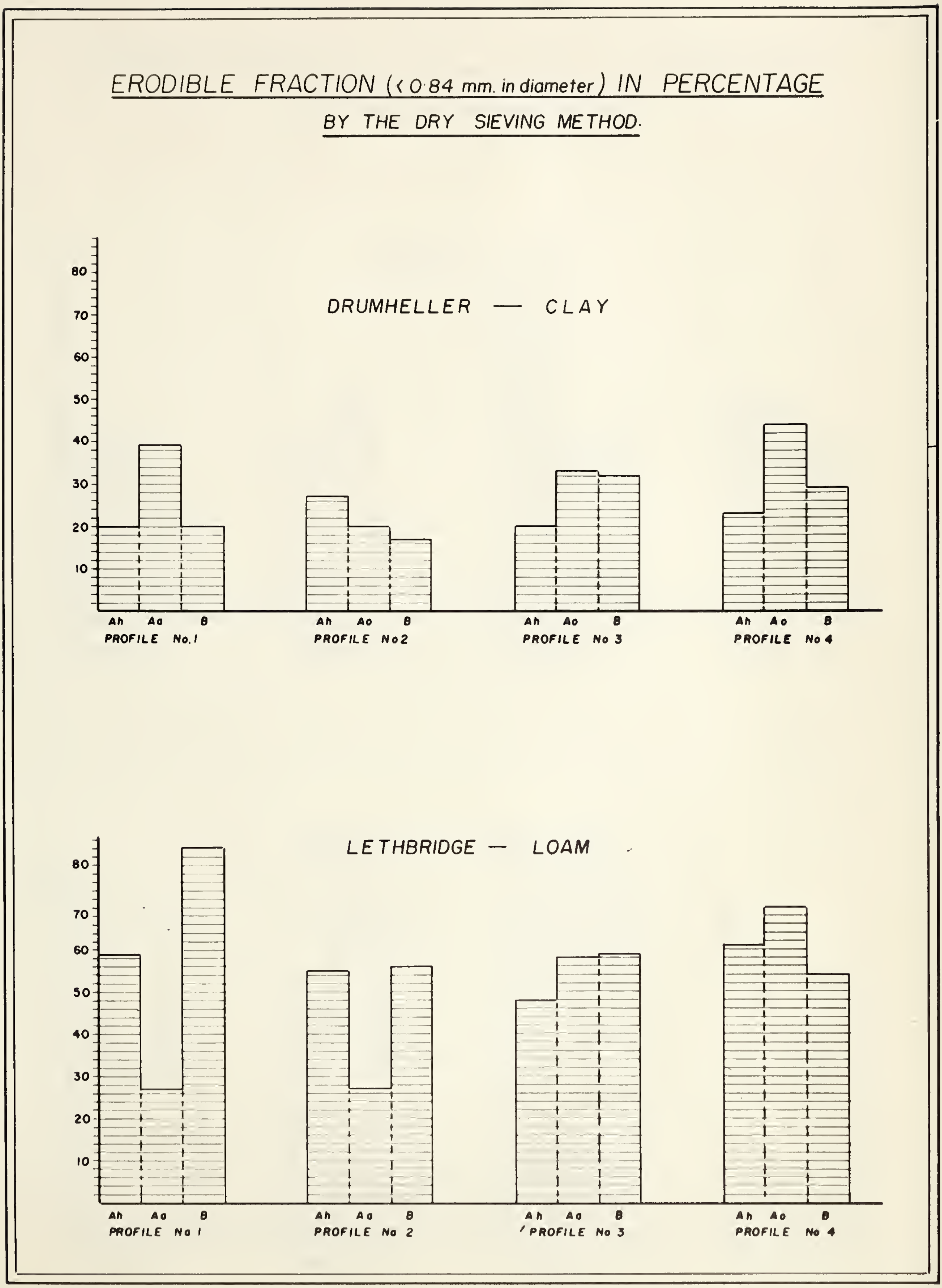

FIGURE 9: PERCENTAGE OF ERODIBLE FRACTION (< 0.84 MM. IN DIAMETER) AS DETERMINED BY CHEPIL - CYLINDRICAL SIEVE (26)

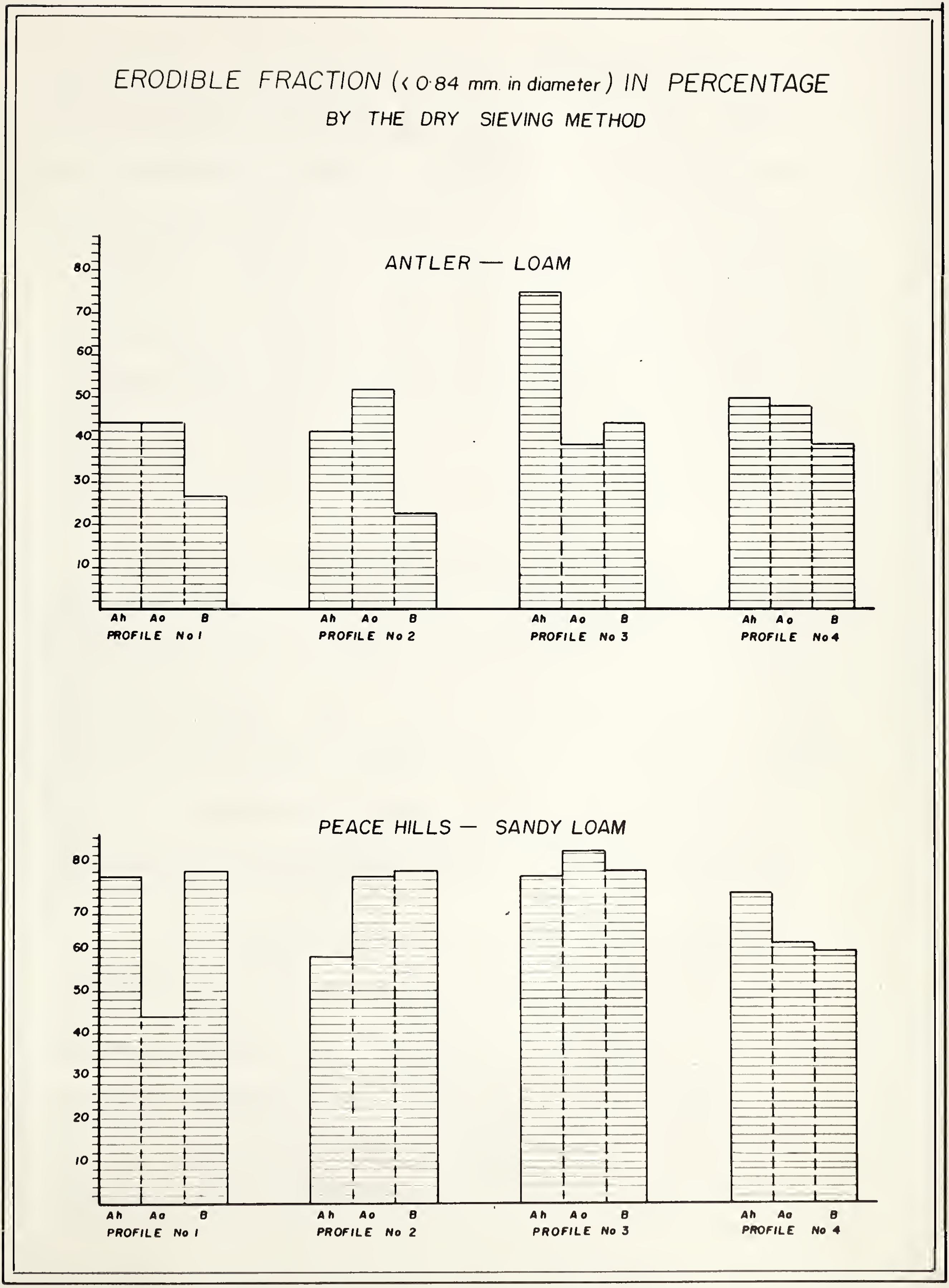

FIGURE 9 (CONT'D)

84 per cent in the B horizon. The B horizon is more erosive than both Ah and Aa horizons. This indicates that both the virgin soil and the cultivated soil may be influenced by erosion. In fact, a layer of drift above the Ah horizons was observed when sampling these soils. The mechanical analyses indicate that virgin soils are relatively lower in their clay content than both Ah and the Aa horizons. Thus it is likely to have a larger erodible fraction.

Data for the Antler loams show that the erodible fraction is 42 to 75 per cent in the Ah, 39 to 52 per cent in the Aa and 23 to 48 per cent in the B horizons. The Aa and B horizons appear to be more resistant to erosion than the Ah horizon. This can be attributed to the high organic matter and the small mean weight-diameter in the Ah horizon.

In the Peace Hills soils the erodible fraction is 58 to 77 per cent in the Ah, 44 to 83 per cent in the Aa and 59 to 78 per cent in the B horizon respectively. This soil type appears to be the least resistant to erosion as a result of its high sand content.

The difference in average erodible fraction content in the soil samples are shown in Table 14, while the analysis of variance results are shown in Table 15.

TABLE 14

Average Erodible Fraction

Soil type	Ah	Aa	B	Average
Drumheller clay	23	34	25	24
Lethbridge loam	56	45	63	54
Antler loam	53	33	46	34
Peace Hills sandy loam	71	73	66	70

L.S.D. (Types) = 13

TABLE 15

Summary of the Analysis of Variance Results for the Dry Sieving Data

Source of variation	F-value
Replicates	1.1
Types	21**
Horizons	0.36
Horizons x Types	2.1

** Significant at one per cent level

We recall from our literature review that soils with more than 50 per cent erodible material are subject to serious erosion. Thus it is quite clear from the above table that the Peace Hills soil is the most erosive followed by the Lethbridge, Antler and Drumheller soils. This seems to follow the mechanical composition, that is, the more finer textured the soil, the more resistant it becomes to erosive winds.

The statistical analysis does not suggest significant variations among the different horizons, however, the cultivated soil in the Drumheller (Aa) is relatively less resistant to erosion than the Ah and B horizons. In comparison the Aa horizons of the Lethbridge and Antler are more resistant to erosion than their corresponding Ah and B horizons. Very small variations are noted between the Ah and Aa in the Peace Hills soils. The B horizon in this soil type, however, is slightly more resistant to erosion than the Ah and Aa samples.

POT EXPERIMENT

The main objectives of the pot experiment were as follows:

1. To determine the relative productivity of the Ah, Aa and B horizons in each soil type.
2. To determine the effect of different nitrogen and phosphorus treatments on the yield of barley.
3. To determine the response of barley in the three horizons under investigation to both nitrogen and phosphorus fertilizers.

For this factorial experiment the form of analysis shown in Table 16 was used for statistical analysis for each soil. For yields see Table 17.

TABLE 16

Form of Statistical Analysis Showing the Source of Variation and the Degrees of Freedom

SOURCE OF VARIATION	DEGREES OF FREEDOM
Locations (replicates)	3
Horizons	2
Error (1)	6
Nitrogen	2
Phosphorus	2
Nitrogen x Phosphorus	4
Horizon x Nitrogen	4
Horizon x Phosphorus	4
Horizon x Phosphorus x Nitrogen	8
Error (2)	72
TOTAL	107

TABLE 17

OVEN DRY WEIGHTS OF BARLEY PLANTS IN THE POT EXPERIMENT I - DRUMHELLER CLAY

SOIL HORIZON	TREATMENT	WEIGHT IN GRAMS OF THE FOUR REPLICATES				AVERAGE
		REP. 1	REP. 2	REP. 3	REP. 4	
	NoPo	4.5	4.5	3.6	5.3	4.5
	N1Po	6.5	5.0	4.8	7.2	5.9
	N2Po	5.8	7.0	4.3	8.0	6.0
AH	NoP1	7.0	4.5	5.5	5.0	5.5
HORIZON	NoP2	6.0	4.5	4.0	6.5	5.2
	N1P1	7.8	5.5	7.4	8.0	7.2
	N1P2	7.5	7.0	6.2	8.8	7.4
	N2P1	8.0	6.5	6.8	9.0	7.6
	N2P2	8.5	8.2	6.5	9.6	8.2
	NoPo	5.2	4.8	5.0	7.4	5.6
	N1Po	7.0	7.2	6.5	8.4	7.4
	N2Po	6.0	8.0	8.0	7.8	7.4
AA	NoP1	5.0	4.8	5.5	8.2	5.9
HORIZON	NoP2	6.0	5.0	5.5	7.2	5.9
	N1P1	7.5	8.0	8.5	8.6	8.2
	N1P2	6.5	8.8	7.5	8.6	7.9
	N2P1	6.8	9.0	7.7	8.5	8.0
	N2P2	7.0	9.1	8.2	8.5	8.2
	NoPo	2.5	3.5	3.3	3.0	3.1
	N1Po	3.5	4.3	3.5	4.2	3.9
B	N2Po	4.0	5.0	5.0	5.2	4.8
	NoP1	3.5	3.5	4.0	3.0	3.5
HORIZON	NoP2	3.5	4.0	3.0	4.8	3.8

TABLE 17 (CONT'D)

SOIL HORIZON	TREATMENT	WEIGHT IN GRAMS OF THE FOUR REPLICATES				AVERAGE
		REP.1	REP.2	REP.3	REP.4	
B Horizon	N1P1	6.2	6.2	7.2	3.8	5.9
	N1P2	6.5	7.5	7.5	7.0	7.1
	N2P1	7.0	8.5	8.7	7.6	7.9
	N2P2	8.0	6.6	8.8	8.5	7.9
II - Lethbridge Loam						
AH Horizon	NoPo	3.5	2.7	3.5	3.2	3.2
	N1Po	5.5	5.0	4.0	4.0	4.6
	N2Po	5.4	5.0	5.2	4.5	5.0
	NoP1	4.0	2.6	4.0	4.5	3.8
	NoP2	4.3	3.0	4.4	4.0	3.9
	N1P1	5.8	4.5	7.0	5.3	5.6
	N1P2	5.7	4.5	6.3	6.0	5.6
	N2P1	6.4	5.0	6.5	6.0	5.9
	N2P2	7.3	5.2	6.7	5.2	6.1
AA Horizon	NoPo	1.6	2.0	4.5	2.5	2.6
	N1Po	2.8	4.0	5.0	4.0	3.9
	N2Po	3.7	4.0	5.4	4.4	4.4
	NoP1	2.2	5.0	4.3	3.0	3.6
	NoP2	2.2	3.0	4.2	3.8	3.3
	N1P1	3.3	5.8	6.6	5.0	5.2
	N1P2	4.0	6.1	6.8	6.0	5.7

TABLE 17 (CONT'D)

SOIL HORIZON	TREATMENT	WEIGHT IN GRAMS OF THE FOUR REPLICATES				AVERAGE
		REP.1	REP.2	REP.3	REP.4	
	N2P1	4.0	7.0	6.0	5.8	5.7
	N2P2	5.4	6.5	6.0	5.8	5.9
B HORIZON	NoPo	3.3	3.5	2.0	3.5	3.1
	N1Po	5.0	4.0	3.4	4.2	4.1
	N2Po	2.1	6.0	4.5	4.0	4.1
	NoP1	2.8	3.0	3.0	3.3	3.0
	NoP2	2.5	4.0	2.3	3.5	3.1
	N1P1	5.5	5.3	5.5	6.2	5.6
	N1P2	5.1	5.8	5.8	6.5	5.8
	N2P1	5.7	6.0	5.3	5.9	5.7
	N2P2	5.7	6.0	5.5	7.0	6.0
III - ANTLER LOAM						
AH HORIZON	NoPo	5.5	6.2	5.0	5.0	5.4
	N1Po	5.2	6.9	5.5	5.2	5.7
	N2Po	6.5	7.3	5.3	5.6	6.2
	NoP1	6.0	5.3	5.3	5.8	5.6
	NoP2	8.0	6.3	4.8	5.5	6.1
	N1P1	5.0	6.5	6.6	6.2	6.1
	N1P2	5.5	6.0	6.5	7.0	6.2
	N2P1	6.5	6.3	6.0	7.6	6.6
	N2P2	6.3	7.4	6.4	7.8	6.9

TABLE 17 (CONT'D)

SOIL HORIZON	TREATMENT	WEIGHT IN GRAMS OF THE FOUR REPLICATES				AVERAGE
		REP. 1	REP. 2	REP. 3	REP. 4	
	NoPo	5.5	4.5	5.5	4.2	4.9
	N1Po	4.1	5.3	5.8	5.2	5.1
	N2Po	4.5	5.5	5.1	6.5	5.4
AA	NoP1	3.8	3.9	5.8	5.5	4.7
HORIZON	NoP2	4.0	5.0	4.8	5.5	4.8
	N1P1	3.2	5.0	5.5	6.0	4.9
	N1P2	4.0	6.3	5.5	7.0	5.7
	N2P1	3.5	6.8	6.2	7.2	5.9
	N2P2	4.0	8.0	7.0	7.5	6.6
	NoPo	3.5	2.3	3.2	1.8	2.7
	N1Po	4.9	3.3	4.3	3.6	4.0
	N2Po	5.2	4.0	4.8	3.1	4.3
B	NoP1	4.8	2.3	6.2	2.5	3.9
HORIZON	NoP2	4.0	2.5	4.5	3.0	3.5
	N1P1	5.5	5.0	6.5	6.5	5.9
	N1P2	5.0	6.2	6.5	5.0	5.7
	N2P1	6.5	5.8	7.0	5.7	6.2
	N2P2	4.1	7.2	8.0	6.8	6.5

IV - PEACE HILLS SANDY LOAM

	NoPo	3.5	3.0	3.0	2.0	2.9
	N1Po	4.2	4.0	4.0	2.5	3.7
	N2Po	4.0	3.0	3.2	2.1	3.1

TABLE 17 (CONT'D)

SOIL HORIZON	TREATMENT	WEIGHT IN GRAMS OF THE FOUR REPLICATES				AVERAGE
		REP. 1	REP. 2	REP. 3	REP. 4	
AH HORIZON	NoP1	3.2	3.0	3.8	2.0	3.0
	NoP2	4.2	3.8	3.5	2.4	3.5
	N1P1	5.5	3.5	4.4	3.0	4.1
	N1P2	5.8	4.4	3.2	3.2	3.9
	N2P1	5.5	4.8	4.5	3.0	4.4
	N2P2	5.0	5.1	4.8	3.5	4.6
AA HORIZON	NoPo	2.0	3.3	2.6	6.0	3.5
	N1Po	2.2	4.0	3.0	6.5	3.9
	N2Po	2.7	4.8	2.0	6.0	4.3
	NoP1	2.9	3.5	3.8	5.0	3.8
	NoP2	2.8	3.8	2.8	5.2	3.7
	N1P1	4.6	4.4	3.0	6.0	4.5
	N1P2	5.5	3.4	4.3	6.3	4.9
	N2P1	5.0	5.0	4.0	5.8	4.9
	N2P2	5.3	3.5	4.2	6.2	4.8
B HORIZON	NoPo	1.5	1.5	1.7	0.80	1.4
	N1Po	4.0	2.3	3.5	2.2	2.9
	N2Po	3.0	2.0	3.8	2.2	2.7
	NoP1	1.2	2.0	2.0	1.0	1.5
	NoP2	1.0	6.5	2.2	1.2	2.7
	N1P1	4.8	4.5	3.2	2.5	3.7
	N1P2	5.0	4.5	4.2	2.3	4.0
	N2P1	5.0	4.6	4.0	3.2	4.2
	N2P2	4.5	4.3	4.2	4.2	4.3

In Table 17 is recorded a complete list of the pot experiment results (432 observations) grouped according to soil type, while the statistical analysis is summarized in Table 18.

TABLE 18

Summary of the Statistical Analysis of the Pot Experiment Data

Source of Variation	F-Value			
	Drumheller	Lethbridge	Antler	Peace Hills
Replicates	0.91	0.48	0.50	0.085
Horizon	5.2*	0.36	3.5	1.3
Nitrogen	37**	140**	26**	28**
Phosphorus	50.0**	41**	12**	12**
Nitrogen x Phosphorus	4.0**	3.4*	0.97	1.1
Horizon x Nitrogen	4.3**	5.3	3.7**	1.7
Horizon x Phosphorus	6.3**	3.2	3.3*	0.80
Horizon x Nitrogen x Phosphorus	1.9	0.79	0.29	0.56

** Significant at one per cent level
* Significant at five per cent level

Throughout the course of the experiment and as shown in the results, both the Ah and Aa soils in the Drumheller area produced the highest vegetative growth and yield compared with other soils. The Peace Hills sandy loam soils were the least productive as

A result of their coarse texture. No significant variations in the weights of barley are noted in the different horizons with the exception of the Drumheller soils (Table 18). In this latter soil type both the Ah and Aa horizons are significantly higher in their productivity than the B horizon. The check yield in the cultivated soils of Drumheller is about one and a quarter times that of the Ah and about twice as much as the B horizon (Table 17). The slightly higher productivity of Aa in comparison with Ah may be attributed to the use of commercial fertilizers and the disturbance of the natural fine-textured clay. However, it is also recalled from the chemical analysis that the Aa horizon was slightly higher in organic matter than the Ah horizon.

Though no significant variations are noted among the three horizons under investigation in Lethbridge, Antler, and Peace Hills samples, more information concerning productivity will be noted in discussing the interactions. It is obvious that for the different horizons, the main "plots", the degrees of freedom for error is small when compared with the degrees of freedom for error used in

ASSESSING THE INTERACTIONS, AND THEREFORE LESS ACCURATELY MEASURED. SUFFICE IT TO MENTION AT THE PRESENT MOMENT THAT THE AA HORIZON OF THE LETHBRIDGE SOIL IS SLIGHTLY INFERIOR IN PRODUCTIVITY TO BOTH THE AH AND B HORIZONS. ON THE OTHER HAND, THE AA HORIZON IN THE PEACE HILLS SOILS IS SLIGHTLY HIGHER IN PRODUCTIVITY THAN THE AH HORIZON. FINALLY, IN THE ANTLER SAMPLES, THE AH IS THE MOST PRODUCTIVE FOLLOWED BY THE AA AND THE B HORIZON. IT IS THUS INTERESTING TO NOTE THAT ON THE AVERAGE THE PRODUCTIVITY OF HORIZONS OF ANY PARTICULAR SOIL TYPE IS PRIMARILY ASSOCIATED WITH THE PER CENT ORGANIC MATTER PRESENT IN THE SOIL.

THE BARLEY PLANTS GROWN IN THE DRUMHELLER SOILS EXHIBITED GREATER RESPONSES TO NITROGEN THAN PHOSPHORUS INDICATING A GREAT NEED FOR NITROGEN FERTILIZERS. THIS IS ILLUSTRATED IN TABLE 19.

TABLE 19

NITROGEN-PHOSPHORUS INTERACTION IN DRUMHELLER SOILS

NITROGEN	PHOSPHORUS Po	P1	P2
No	4.4*	5.0	5.0
N1	5.7	7.0	7.4
N2	6.2	7.8	8.1

L.S.D. = 0.92

* YIELD IN GRAMS. AVERAGE OF TWELVE POTS.

The addition of phosphorus did not significantly increase yield over that of the check, while a great response occurred by adding nitrogen at fifty pounds per acre level. The addition of nitrogen at one hundred pound per acre level did not significantly increase the yields over that of the fifty pound level.

The response of barley to fertilizer nitrogen and phosphorus differed from one horizon to another as illustrated in Tables 20 and 21.

TABLE 20

Nitrogen-Horizon Interaction in Drumheller Soils

	Nitrogen		
Horizon	No	N1	N2
Ah	5.1	6.8	7.3
Aa	5.8	7.8	7.9
B	3.5	5.6	7.9

L.S.D. = 0.92

TABLE 21

Phosphorus-Horizon Interaction in Drumheller Soils

	Phosphorus		
Horizon	Po	P1	P2
Ah	5.5	6.7	6.9
Aa	6.8	5.8	7.3
B	3.9	5.8	6.3

L.S.D. = 0.92

It is obvious from Tables 20 and 21 that both the Ah and Aa did not show response to nitrogen at the one hundred pound per acre level and exhibited significant responses to the fifty pound per acre level. The B horizon showed response to both levels. The Ah and B horizons responded to the forty pound per acre P_2O_5 level while in the case of the Aa horizon it resulted in only a slightly higher yield. The addition of eighty pounds P_2O_5 caused insignificant increases over the forty pound treatment in the yield of all horizons.

The absence of interaction (horizon-nitrogen and horizon-phosphorus) in both the Lethbridge and the Peace Hills soils (Table 17) clearly indicates that the three horizons under investigation in both soil types are of equal productivity. However, the overall response to nitrogen and phosphorus in the Lethbridge soils is illustrated in the following table.

TABLE 22

Nitrogen-Phosphorus Interaction in Lethbridge Soils

	Phosphorus		
Nitrogen	Po	P1	P2
No	3.0	4.2	4.5
N1	3.5	5.5	5.8
N2	3.4	5.7	6.0

L.S.D. = 0.80

It is noted from the above table that the Lethbridge soils showed more response to phosphorus than to nitrogen fertilizer. This may be attributed to the possible lack of available phosphorus in these soils. No significant increases in yield are noted by adding the high levels of both nitrogen and phosphorus. That is, one hundred pounds per acre nitrogen and eighty pounds per acre P_2O_5.

The horizon fertilizers interaction in the Antler loam soils is illustrated below.

TABLE 23

Horizon-Nitrogen Interaction In Antler Soils

	Nitrogen		
Horizon	No	N1	N2
AH	5.7	6.0	6.6
AA	4.8	5.2	6.0
B	3.4	5.2	5.7

L.S.D. = 1.2

TABLE 24

Horizon-Phosphorus Interaction In Antler Soils

Horizon	Po	P1	P2
Ah	5.8	6.1	6.5
Aa	5.1	5.2	5.7
B	3.7	5.3	4.4

L.S.D. = 12

The Ah and Aa horizons being naturally high in organic matter did not respond to phosphorus and nitrogen fertilizers. On the other hand the B horizon showed a significant response for both the fifty pound per acre nitrogen and the forty pound per acre P_2O_5.

In concluding this section on the pot experiment it can be noted that the Lethbridge region has suffered the most as a result of wind erosion and cultivation. The fertility of the Aa horizon is slightly lower than the B. It should be borne in mind that the low productivity of the Peace Hills soils is primarily due to its coarse texture. On the other hand the Drumheller soils are the most productive. However, further erosion will undoubtedly reduce the productivity since the B horizon is significantly lower in productivity than both Ah

and Aa horizons.

The Drumheller soils exhibited the need for nitrogen fertilizers, while the Lethbridge soils should be supplied with phosphorus. The Ah and Aa soils in the Peace Hills did not show the need for nitrogen or phosphorus. This is in contrast to the B horizon where nitrogen at fifty pounds per acre level and P_2O_5 at forty pounds level are required.

The organic matter percentage in any soil horizon is found to be a main factor affecting productivity of soils of any particular type.

Finally, from Table 17 it can be observed that in Drumheller, the addition of nitrogen at one hundred pounds per acre allowed the B horizon to be as productive as the Ah horizon. No additions are needed for the Aa horizon. In Lethbridge, the Aa horizons needed fifty pounds per acre nitrogen or one hundred pounds per acre P_2O_5 to produce as much as the Ah horizon, while no additions are required for the B horizon. The Aa horizon in Antler exhibited the need for one hundred pounds per acre of nitrogen while the B horizon needed fifty pounds

PER ACRE NITROGEN AND FORTY POUNDS PER ACRE P_2O_5. FINALLY, THE Aa HORIZON IN THE PEACE HILLS DID NOT REQUIRE ADDITIONS, WHILE THE B HORIZON NEEDED FIFTY POUNDS PER ACRE NITROGEN AND FORTY POUNDS PER ACRE P_2O_5.

SUMMARY

1. The total wind mileages in the southern portion of the province are much higher than those in the northern portion. The Lethbridge region in particular is exposed to winds of extremely great velocities - much in excess of those in any other area in the province.
2. The high wind speeds in the late spring and early summer cause serious hazards in Alberta since at this time of the year the soils are bare and dry, and crops have not yet grown enough to protect the soil.
3. Erosive winds, that is, wind causing erosion during the troublesome months, occur more than fifty per cent of the time at Calgary and Lethbridge.
4. Wind erosion and cultivation have not significantly altered the organic matter and total nitrogen content in both the Drumheller and

the Lethbridge areas. Reduction in the organic matter in Antler loam soils is primarily brought about by cultivation. The cultivated soils in the Lethbridge area are slightly lower in organic matter than the B horizon.

5. No significant differences are noted for the total phosphorus in the various horizons except in the Antler soils.

6. The calcium carbonate equivalent in the Lethbridge soil is surprisingly higher in the Aa than in the B horizon indicating that wind erosion has resulted in the loss of all the Ah and probably most of the B horizon.

7. The Lethbridge soils exhibit more variation in texture, as a result of cultivation and erosion, than the other profiles. The sand content increased at the expense of a decrease in the silt content.

8. The mechanical stability of structure as measured by either the wet or the dry sieving indicated that the Aa horizon in the Drumheller soils is less resistant to erosion than both the Ah and B horizons. This is in contrast to the Aa at

Lethbridge where this horizon was the most resistant to erosion as a result of the removal of the erodible fraction. The Peace Hills soils are the least resistant to erosion, however, the low wind speeds in this area and the rare occurrence of erosive winds counteract this erosion hazard.

9. The pot experiment indicated that the soils of Drumheller are the most productive and that Lethbridge soils are suffering most from erosion. The Drumheller soils exhibited the need for nitrogen while the Lethbridge soils exhibited the need for phosphorus. The productivity of different horizons as a whole was found to be associated primarily with the per cent organic matter.

10. The removal of the top soil in the Drumheller area by continuous erosion will require the addition of one hundred pounds of nitrogen per acre to restore the remaining soils to equal fertility. The Lethbridge soils already severely eroded require fifty pounds of nitrogen per acre or one hundred pounds of P_2O_5 per acre. On the other hand, in both the Antler and Peace Hills soils

THAT IS, IN THE RED DEER AND THE EDMONTON AREA, THE REMOVAL OF THE TOP SOIL IS NOT LIKELY TO OCCUR SINCE THESE AREAS ARE EXPOSED TO MODERATE WINDS AND RELATIVELY HIGHER RAINFALL THAN THE SOUTHERN AREAS.

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